October 18, 2006 In response refer to:
2006/04975

Colonel Ronald Light
District Engineer
U.S. Army Engineer District, Sacramento
Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Light:

This document transmits NOAA's National Marine Fisheries Service's (NMFS) amended biological opinion (Enclosure 1) based on our review of the proposed Sacramento River Flood Control Project (SRFCP) Critical Levee Erosion Repair project, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), and their designated critical habitat in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). This amended biological opinion also includes a review of project related effects on the threatened Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*).

On February 24, 2006, Governor Arnold Schwarzenegger issued an emergency proclamation for California's levee system. The proclamation focused on the imminent threat of 24 critical levee erosion sites located in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties. The Governor's declaration directed that additional, potentially critical, sites be evaluated and repaired, and as a result five additional sites were added to the proposed action. The U.S. Army Corps of Engineers Corps proposed to construct 13 sites as part of the Sacramento River Bank Protection project (SRBPP), and the California Department of Water Resources (CDWR) proposed to construct 16 sites. On June, 21, 2006, NMFS issued a biological opinion that concluded, based on the best available scientific and commercial information, the proposed action comprising the 29 sites was not likely to jeopardize the above species or adversely modify the conservation value of designated critical habitat. NMFS also included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to minimize incidental take associated with project activities.

On September 15, 2006, you requested an amendment to the June 21, 2006, biological opinion to extend the length of one site being constructed under the SRBPP, and on October 2, 2006, you made an additional request to add three sites to be constructed by CDWR in the Sacramento River and Butte Creek. The October 2, 2006, request also proposed to permit CDWR to postpone the installation of container plantings for re-vegetation until spring of 2007 instead of October 2006 to improve plant survival.

This amended biological opinion is based on the Corps' September 12, 2006, amended project description; CDWR's September 19, 2006, amended project description, including Standard Assessment Method results and 95 percent design drawings; and a September 20, 2006, CDWR request to amend permits to postpone installing container plantings. A complete administrative record of this consultation is on file at the NMFS Sacramento Field Office. This amended biological opinion includes changes to the following sections of the June 21, 2006, biological opinion: *Consultation History, Description of the Proposed Action, Environmental Baseline, Effects of the Action*, *Incidental Take Statement*, and *Literature Cited*.

Based on the best available scientific and commercial information, the amended biological opinion concludes that the proposed SRFCP Critical Levee Erosion Repair project is not likely to jeopardize the above listed species or adversely modify the conservation value of designated critical habitat. NMFS has also included an amended incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to minimize incidental take associated with project actions. The listing of the Southern DPS of North American green sturgeon became effective on July 6, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d) of the ESA. Because there are no section 9(a) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not apply until a 4(d) regulation become effective.

Also enclosed are amended Essential Fish Habitat (EFH) Conservation Recommendations for Pacific salmon as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.;* Enclosure 2). This document concludes that the SRFCP Critical Emergency Levee Repair project will adversely affect the EFH of Pacific Salmon in the action area and adopts certain of the terms and conditions of the incidental take statement and the ESA Conservation Recommendations of the biological opinion as the EFH Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR ' 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

If you have any questions regarding this correspondence please contact Mr. Howard Brown in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95814. Mr. Brown may be reached by telephone at (916) 930-3608 or by Fax at (916) 930-3629.

Sincerely,

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file: 151422SWR2006SA00115
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Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	U.S. Army Corps of Engineers Sacramento District
ACTIVITY:	Sacramento River Flood Control Project Critical Levee Erosion Repair project
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	2006/04975
DATE ISSUED:	October 18, 2006

I. CONSULTATION HISTORY

On Sept 27, 2001, NOAA's National Marine Fisheries Service (NMFS) issued a biological opinion to the U.S. Army Corps of Engineers (Corps) assessing the effects of the Sacramento River Bank Protection Project (SRBPP) Contracts 42E and 42F on Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), and their designated critical habitat. The biological opinion found that the Contracts 42E and 42F were not likely to jeopardize the continued existence of the previously identified species or adversely modify their designated critical habitat. This biological opinion identified Contract 42E as the proposed action, and only authorized incidental take for the construction of Contract 42E at river mile (RM) 149. The biological opinion required the Corps to limit subsequent SRBPP actions to the 2,760 linear feet (lf) of bank protection identified under Contract 42F until initiating programmatic consultation for the remainder of Phase II of the SRBPP. The biological opinion also required the Corps to develop a standardized assessment approach for determining the effects of SRBPP actions on Federally listed salmonids.

On September 29, 2003, the Corps requested an amendment to the SRBPP biological opinion for Contracts 42E and 42F to use the 2,760 lf of rock revetment placement originally planned for Contract 42F at other high priority sites prior to initiating programmatic consultation for the remainder of Phase II of the SRBPP.

On December 31, 2003, NMFS responded that an amendment was not necessary for exchanging the lf of bank protection originally planned under Contract 42F because the exchange would not affect the Federal action implemented under Contract 42E, and effects to listed anadromous fish and the designated critical habitat of Sacramento River winter-run Chinook salmon and the EFH of Pacific salmon at the substitute sites would not be likely to occur in a manner or to an extent not already considered in the SRBPP biological opinion.

On April 9, 2004, the Corps' environmental management and staff (Scott Clark and Mike Dietl) met with NMFS management and staff (Mike Aceituno and Howard Brown) to discuss the proposed bank protection projects at RMs 56.7 (left) L and 60 L. Topics of discussion included on-site and off-site compensation requirements for adverse impacts to listed anadromous fish and their habitat, and section 7 consultation timelines.

On June 7, 2004, the Corps requested formal consultation with NMFS, pursuant to section 7 of the Endangered Species Act (ESA), for the SRBPP, RM 56.7 L, in Sacramento County, California.

In August, 2004, the Corps issued the final Standard Assessment Methodology (SAM) for the SRBPP pursuant to the requirements of NMFS' 2001 biological opinion for Contracts 42E and 42F. The SAM was developed to address specific habitat assessment and regulatory needs for ongoing and future bank protection actions in the SRBPP action area. The SAM was designed to address a number of limitations associated with previous habitat assessment approaches and provide a tool to systematically evaluate the impacts and compensation requirements of bank protection projects based on the needs of listed fish species. The SAM was developed by the Corps, in consultation with the NMFS, the USFWS, CDFG and CDWR, academic contributions from the University of California at Davis and Humboldt State University, and peer review by sixteen professionals in fishery biology, river geomorphology, and environmental sciences, and engineering.

On August 16, 2004, NMFS notified the Corps, via email, that NMFS' initial analysis indicated that specific timelines for implementing off-site compensation requirements would be required to avoid jeopardizing the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon (CV spring-run Chinook salmon), and Central Valley steelhead (CV steelhead), or adversely modify designated critical habitat.

On August 30, 2004, the Corps provided a letter to NMFS including eight additional conservation measures that outlined timelines and other details for implementing off-site compensation requirements.

On September 8, 2004, NMFS issued a biological opinion for the SRBPP at RM 56.7 L. This biological opinion required the Corps to complete a plan for implementing off-site compensation within 12 months, and to begin construction of the off-site compensation within 30 months. The biological opinion also required the Corps to initiate formal programmatic consultation upon completion of an additional 900 lf of bank protection projects unless immediate public safety risks demonstrated the need to complete additional work.

On August 29, 2005, the Corps, the State of California Reclamation Board (Reclamation Board), the Sacramento Area Flood Control Agency (SAFCA), the U.S. Fish and Wildlife Service

(USFWS), and NMFS held a meeting to discuss SAM applications for bank protection projects anticipated for the Sacramento River, in the Pocket neighborhood of Sacramento, California, between RMs 49.6 and 53.1 (Pocket sites), and for a proposed restoration project on the American River at RM 0.5 right (R).

On September 14, 2005, the Corps led a field trip to the bank protection sites between RMs 49.6 and 53.1 with NMFS staff (Howard Brown) in attendance.

On November 18, 2005, the Corps sent a letter to USFWS and NMFS requesting agreement that habitat enhancement at RM 0.5 R on the American River could serve as off-site compensation for unavoidable adverse impacts to listed fish species affected by the proposed construction of the Pocket sites.

On December 20, 2005, the Corps distributed 90 percent design plans and specifications on the Pocket sites to USFWS, NMFS, and the California Department of Fish and Game (CDFG) for comment.

On January 12, 2006, the Corps received comments from NMFS on the 90 percent plans and specifications for the Pocket sites.

On February 21, 2006, the Corps requested formal consultation with NMFS, pursuant to section 7 of the ESA, for the Pocket sites. This request included a biological assessment prepared for the project.

On February 24, 2006, Governor Arnold Schwarzenegger issued an emergency proclamation for California's levee system. The proclamation focused on the imminent threat of 24 critical levee erosion sites located in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties.

On February 27, 2006, Governor Arnold Schwarzenegger sent a request to President George Bush for a Federal emergency declaration for California's levee system.

On March 6, 2006, Governor Arnold Schwarzenegger issued Executive Order S-01-06, ordering California Department of Water Resources (CDWR) to develop a plan and repair the 24 critical sites.

On March 6, 2006, Governor Arnold Schwarzenegger sent a request to the Corps seeking assistance with the critical erosion site repair.

On March 9, 2006, CDWR awarded engineering and environmental work to the URS Corporation (URS) under existing contract to carry out substantial portions of the levee repair work.

On March 15, 2006, CDWR staff met with representatives of the, USFWS, NMFS, CDFG, Regional Water Quality Control Board (Regional Board), Reclamation Board, and consultants from URS in the Interagency Working Group (IWG) meeting.

On March 22**,** 2006, CDWR received emergency funding totaling $103,355,200 to carry out emergency repairs.

On March 23, 2006, CDWR staff and their consultant, URS, met with representatives of the USFWS, NMFS, CDFG, SAFCA and Steve Chainey, of MIG, to identify the sites, to share preliminary photographs and data from the sites, and to define the regulatory procedures, permits, and analyses that will be required to implement the 24 site repairs. Agency representatives and their consultants described the desire to incorporate seasonally-inundated shallow-water benches, woody debris and aquatic vegetation.

On March 29, 2006, CDWR invited the Corps, USFWS, NMFS and the Federal Emergency Management Agency (FEMA) to participate in a Levee Repair Oversight Committee to streamline coordination with Federal and State agencies on permitting.

On March 31, 2006, the Corps committed to the repair of 10 of the original 24 critical sites, contingent on the Corps receiving approval to accept funding from CDWR. The Corps also indicated it plans to repair an additional four sites in the Pocket area of Sacramento not listed on the critical list.

On April 6, 2006, CDWR Director Lester Snow announces the State will provide approximately $30 million in emergency funding to the Federal government for the Corps to repair 10 of the total 29 critical erosion levee sites.

On April 18, 2006, the Corps provided NMFS with an updated project description and a final SAM analysis (Jones and Stokes 2006b) for the Pocket sites. The update included a modified design for installing instream woody material (IWM) for fish habitat enhancement.

On April 18, 2006, CDWR Director Lester Snow convenes first meeting of the Levee Repair Executive Oversight Committee to ensure close coordination and cooperation among Federal and State regulatory agencies.

On April 19, 2006, CDWR staff and URS met with representatives of the USFWS, NMFS, CDFG, Reclamation Board, and Regional Board to present the results of field reports, preliminary designs for repairs, permits, and analyses that will be required to implement the critical site repairs. CDWR expressed interest in expediting permitting for sites that lack endangered species and have basic constraints.

On April 19, 2006, CDWR conducted a Legislative briefing for Assembly members and/or their staff.

April 20, 2006, CDWR announces addition of five sites to list of 24 critical erosion sites.

On April 28, 2006, URS provided proposed designs to the Federal agencies for four of the critical sites.

On May 1, 2006, NMFS received preliminary SAM results from the Corps for the five additional sites that were not previously analyzed in the SAM assessment for the Pocket sites.

On May 1, NMFS, the Corps, USFWS, and CDWR signed a Memorandum of Understanding (MOU) to expedite the environmental review process so that the proposed critical levee sites could be repaired during the summer of 2006. The MOU included a critical path timeline for completing project designs and environmental permitting.

From May 1 through June 21, 2006, weekly Federal conference calls were held to discuss progress toward meeting the critical path timeline.

On May 2 and May 3, 2006, URS, CDWR, and the Corps, led a site inspection of the proposed levee repair sites to show the USFWS, NMFS, CDFG, and Corps regulatory staff the preliminary project designs and request recommendations to avoid, minimize, or compensate for project-related impacts to special status resources. NMFS provided written and verbal comments on preliminary project proposals for each site.

On May 4, 2006, USFWS and NMFS summarized their design recommendations in an email to the project design team.

On May 8, 2006, the Corps and CDWR provided a draft biological assessment (BA) to NMFS

On May 12, 2006, the Corps and CDWR submitted proposed final project information.

On May 16, 2006, NMFS received a final BA for the five additional SRBPP sites at RMs 26.9, 34.5, 72.2, 99.3, and 123.5.

On May 22, 2006, NMFS received a table from URS containing physical project features for each site.

On May 31, 2006, URS notified NMFS that SAM model results would be completed and submitted to NMFS in 3 groups. The first group would be completed on June 5, 2006, the second group would be completed on June 9, 2006, and the third group would be completed by June 14, 2006.

On June 8, NMFS issued a draft biological opinion for the Sacramento River Flood Control Project Critical Levee Erosion Repair project.

On June 9, URS provided NMFS with preliminary SAM model results for 11 CDWR sites along the Sacramento River.

On June 12, 2006, the Corps provided NMFS with agency comments on the draft biological opinion for the Sacramento River Flood Control Project Critical Levee Erosion Repair project.

On June 12, 2006, NMFS provided the Corps with a verbal acceptance of the comments and agreed to make the suggested changes.

On June 14, 2006, CDWR provided NMFS with agency comments on the draft biological opinion for the Sacramento River Flood Control Project Critical Levee Erosion Repair project.

On June 15, NMFS provided CDWR with written responses to their June 14, 2006, comments on the draft biological opinion for the Sacramento River Flood Control Project Critical Levee Erosion Repair project. NMFS agreed to most of the suggested changes, but maintained that fishery monitoring shall be incorporated into the CDWR monitoring plan.

On June 19, URS provided NMFS with revised SAM results for all CDWR sites.

NMFS issued a biological opinion on June 21, 2006.

On September 15, 2006, the Corps requested an amendment to the June 21, 2006, biological opinion to extend the length of one site to be constructed by the SRBPP at RM 53.1, left.

On October, 2, 2006, the Corps, requested an amendment to included an additional three sites to be constructed by CDWR, and to permit CDWR to postpone the installation of container plantings at all of their sites until spring 2007 to improve tree survival. The three additional sites are on the Sacramento River at RM 43.3 and 56.1, and on Butte Creek at RM 14.

This biological opinion is based on information provided in the BAs; discussions held with the Corps, CDWR, USFWS, CDFG, URS, and SAFCA; field reviews of the erosion sites, SAM analyses; and engineering designs. A complete administrative record of this consultation is on file at the NMFS Sacramento Area Office.

II. DESCRIPTION OF THE PROPOSED ACTION

As a result of imminent threat of catastrophic levee failure, Governor Arnold Schwarzenegger declared a State of emergency for the California Levee system and ordered the immediate repair of 24 critical levee erosion sites in the Sacramento River Flood Control Project (SRFCP), in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties. The SRFCP consists of approximately 980 miles of levees, plus overflow weirs, pumping plants, and bypass channels that protect urban and agricultural lands in the Sacramento Valley and the Sacramento-San Joaquin River Delta (Delta). The Governor's declaration directed that additional, potentially critical, sites be evaluated and repaired, and as a result five additional sites were added. However, three of the sites, in Cache Creek, and are part of a separate planning effort that has already completed section 7 consultation

At the time of the Governor's emergency declaration, the Corps had been planning to construct eight Pocket sites. Five of the Pocket sites are identified in the Governor's emergency declaration, and the other three are sub-critical sites and proposed to meet FEMA 100-year flood protection criteria. The three FEMA sites will be included in this effort to repair the critical levee sites. Therefore, a total of 29 levee erosion repair projects are included in the original project description. The Corp's SRBPP is the lead design and implementing entity for 13 of the 29 sites. CDWR is the lead implementing entity for 16 of the 29 sites.

The Corps September amendment to the project description includes extending the length of one site being constructed under the SRBPP; add three sites to be constructed by CDWR; and to permit CDWR to postpone the installation of container plantings until spring of 2007 instead of October, 2006, to improve their survival conditions. The amended project description brings the total number of emergency repair projects to 32 sites.

All sites were selected based on a comprehensive erosion site evaluation prepared by Ayres and Associates (2005) for the Corps. The evaluation was made based on field surveys and quantitative ranking of characteristics, such as bank slope, bench width, length and location of erosion, radius of curvature, bank stability, dynamic geomorphology, vegetation cover, tree hazards, soil type, water velocity, wave action, economic factors, human use, seepage potential, and tidal fluctuation. Although the engineering and environmental solutions for each of these sites will differ somewhat, the types of erosion sites, the locations of the sites, the environmental resources of the sites, and the types of repair and restoration methods will be similar.

A. Project Description

The proposed action is to place rock and wood revetments along the waterside slope of each erosion site. One repair along the Sacramento River will be a set-back levee and will not require in-river construction. Project locations are shown on Figure 1. The proposed levee repair work is designed to halt erosion, minimize the loss of riparian vegetation and nearshore aquatic habitat resulting from construction activities, prevent the eventual loss of nearshore aquatic habitat and riparian habitat that probably would occur if the project were not constructed, and provide compensation, if needed, for unavoidable impacts to existing riparian habitat and nearshore aquatic habitat.

The bank protection measures generally would consist of: (1) reinforcement of the bank toe with rock riprap; (2) placement of a mixture of soil and rock on top of the toe riprap to create a bench that slopes at a 10:1 ratio to the water; (3) placement of rock and soil along the upper slope, and covering the rock with soil; (4); anchoring IWM and brush bundles along the waterside edge of the bench, on the bench surface, and on the bank slope to enhance fish habit; and (5) planting the bench and the upper slope with vegetation to increase bank protection and establish riparian habitat.

The bank protection projects will repair bank and levee erosion and restore and enhance the riparian and shaded riverine aquatic (SRA) habitat. Generally, this will be accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features. This design, which has been successfully employed along the lower Sacramento and American Rivers, will recreate the elements of natural SRA habitat that otherwise would be lost as a result of project construction activities and continued erosion.

The bench design functions are to repair existing scour, to provide a buffer against extreme toe scour, to develop a surface and soil for plantings, and to provide shallow-water habitat for juvenile fish rearing and refugia. The roughness factor associated with grown-out plantings will reduce both flow velocities and shear stress against the bank. The plantings also provide SRA habitat. The planted bench feature will include IWM, a variable shoreline, and riparian vegetation that will mimic the ecosystem functions of natural SRA habitat, except that it will not contain natural erodible substrate. Existing on-site IWM will be retained to the fullest extent possible. The bench will provide a platform to anchor added IWM structures for fish habitat, and will vary in height to provide seasonally flooded areas and velocity refugia at a variety of flow conditions.

Hydrologic assessment of Sacramento River Basins indicated that flows sufficient to inundate the benches are likely to occur in most years from January through March. During extremely high flow years, the benches may be inundated as early as November to as late as July. The benches typically will not be inundated during the summer and fall months. The bench will typically not be inundated under any flow scenario from the beginning of July through mid-November.

Living and dead IWM would be placed along the sites to create diverse fish habitat features and refugia at low flow conditions. IWM will be installed to achieve at least a 40 percent shoreline coverage both above and below the mean summer water surface elevation (MSW). IWM will be anchored either by cabling trees to the project surface or by incorporating IWM into riprap. Additional IWM may be placed to compensate for unavoidable impacts to existing conditions. IWM structures would be at least 15 feet long and 10 feet wide, and would retain limbs and root wads, to the extent feasible, for maximum habitat value. IWM would be placed on the surface of the bench and anchored with rock revetment or cables. All branches, limbs and twigs would be retained to the extent practicable to maintain the size, volume, and complexity. Cabled IWM may be sheered straight to allow a flat alignment of each finished IWM piece against the finished riprap surface. The Corps and CDWR environmental representatives in coordination with NMFS and USFWS would determine the most beneficial placement of IWM during construction. IWM generally will be installed at all sites upstream from RM 32.5. From RM 32.5 downstream, and at sites in Cache and Steamboat Slough, emergent vegetation will be planted into bench features in lieu of installing additional IWM in order to minimize the likelihood of increasing structural predator cover to protect Federally listed threatened Delta smelt (*Hypomesus transpacificus*).

Standing and fallen trees at the project sites would be protected in place to the maximum extent possible, and all disturbed areas would be protected with erosion control measures such as hydro seeding and plug plantings. Where necessary, clearing of smaller vegetation from the levee slope would be accomplished using small equipment and/or hand tools. Some pruning of trees may be required during the construction phase. If IWM is removed to install bank protection features, it will be anchored back in place and incorporated into supplemental IWM installation. Exotic species may be removed, and the area replanted with native species appropriate for the location and elevation on an acre-for-acre basis.

Riparian trees and shrubs would be planted along the project sites at elevations extending from near the summer water level, towards the top of the bank. Vegetation generally will be planted on two-to five-foot centers, in three to four zones. Planting zones may include emergent marsh, emergent bench, transition slope, riparian bench, and levee slope. Typical planting schedules, including species by zone, and propagation method are shown in Appendix A, Figures 14, 20, and 23. Generally, large container plants and live pole cuttings will be collected from areas adjacent to the project site or from riparian habitats within the Sacramento Valley at sites within a 50-mile radius of the project site. A nursery experienced with native plant collection and propagation would grow container stock. Plant collections would be conducted in a manner that results in minimal impacts on the source plants and surrounding habitat.

During construction, most bank protection work downstream from RM 80, except planting, staging and construction activities would be conducted on the waterside of the riverbank from a barge or on top of the fill material. The contractors would use the top of the levee and adjacent grassy areas for staging of vehicles and plant materials only if necessary. Upstream from RM 80, barge access is difficult and most construction access will be from the levee surface. Access points will be limited to minimize shoreline and riparian disturbance. Use of construction equipment on the berm or landside may be used to place rock or soil in order to minimize the loss of riparian vegetation.

The contractor would construct the bank protection sites from cranes mounted on barges in the Sacramento River, or from the levee surface. The contractor would first place rock revetment at the toe of the levee slope. Then the contractor would begin placing a combination of rock and sandy soil to construct a bench. Once the contractor has completed the bench, soil would be placed over the bench area for planting medium. The contractor may choose to use excavators, loaders, and other construction equipment on the construction area once the rock revetment is above the water surface.

Once construction of the bench is completed, the contractor would begin placing fill materials, as well as installing the IWM and plantings on the sites. The contractor could then decide to place fill material along the entire length of the site and place the IWM and plantings, or they could decide to construct only a section at a time, depending on material and equipment availability, or feasibility of construction.

Incorporation of environmental features that restore riparian and SRA habitat is a key aspect of the proposed action. As a result, off-site compensation and/or mitigation for impacts on these types of habitats from project construction activities will be implemented only to the extent that the project design does not fully offset these impacts.

Overall, the project would reinforce approximately 25,801 lf of shoreline, covering approximately 50.9 acres, with 26.4 acres being below the MSW. The area above the MSW will be covered with soil and planted with riparian vegetation. Seasonally inundated benches will total approximately 11.6 acres. Approximately 6,795 lf of IWM will be placed both above the MSW and 7,346 lf will be placed below the MSW. Exact amounts are subject to minor change because high river flows during the project design period may lead to underestimates of eroded shoreline lengths. If project lengths increase, the application of conservation measures will be extended accordingly.

1. Corps SRBPP Sites

The Corp's SRBPP will construct bank protection repairs at thirteen sites, along the Sacramento River between RMs 26.9 and 123.5. The Corps is the Federal lead agency, and the California Reclamation Board is the State agency for non-Federal responsibilities and cost sharing. The SRBPP is a continuing construction project, authorized by the Flood Control Act of 1960, to provide protection for the existing levees and flood control facilities of the SRFCP.

The Corps will construct eight sites in the Pocket neighborhood near the city of Sacramento, between RM 49.6 and 53.1, and five additional sites that are located in the Sacramento River between RM 26.9 and 123.5. The projects vary in length from approximately 120 lf to 1,800 lf, and, including the September, 2006, amendment to increase the length at RM 53.1, total approximately 9,197 lf. The proposed action is intended to repair critical erosion sites, and to meet FEMA 100-year flood protection standards while preserving and enhancing natural resources values for Federally listed anadromous fish. The bank protection would be designed to control erosion, restore riparian and SRA habitat, and create seasonally inundated shallow-water rearing habitat. Project locations and design features for each levee repair site are shown in Table 1. The Corps September amendment to the project description extended the length of RM 53.1 from 120 feet to 470 feet. Appendix A, Figures 1 through 13 show cross sectional profiles for each site and illustrate or describe proposed bank protection and environmental features.

2. CDWR Sites

CDWR will construct bank protection repairs at sixteen sites in the SRFCP. Ten sites are along the Sacramento River, two sites are along the Bear River, two sites are along Cache Slough, and one sight is along Steamboat Slough. One site, along the Sacramento River at RM 145.9 involves construction of a set-back levee to avoid adverse impacts to sensitive aquatic resources. The projects vary in length from approximately 130 lf to 2,500 lf, and total approximately 16,604 lf of shoreline, excluding the length of the set-back levee. The purpose of the action is to restore eroded levees so that they can reliably protect life and property in Sacramento's Central Valley while protecting environmental values and compensating adverse effects on environmental resources. The completion of these levee repair measures, along with other efforts led by the Corps and SAFCA, will help restore the SRFCP. The CDWR projects will be permitted under one or a combination of Nationwide Permits (NWP), including NWP 3 (maintenance) and/or NWP 13 (bank stabilization). Additional IWM may be placed to compensate for unavoidable impacts to existing conditions. Project locations and design features for each levee repair site are shown in Table 1. Table 2 shows the sites that were added as part of the September amendment request. Appendix A, Figures 14 through 31 show cross sectional profiles for each site and illustrate or describe proposed bank protection and environmental features. A cross sectional profile for a set-back levee at RM 145.9 is not included.

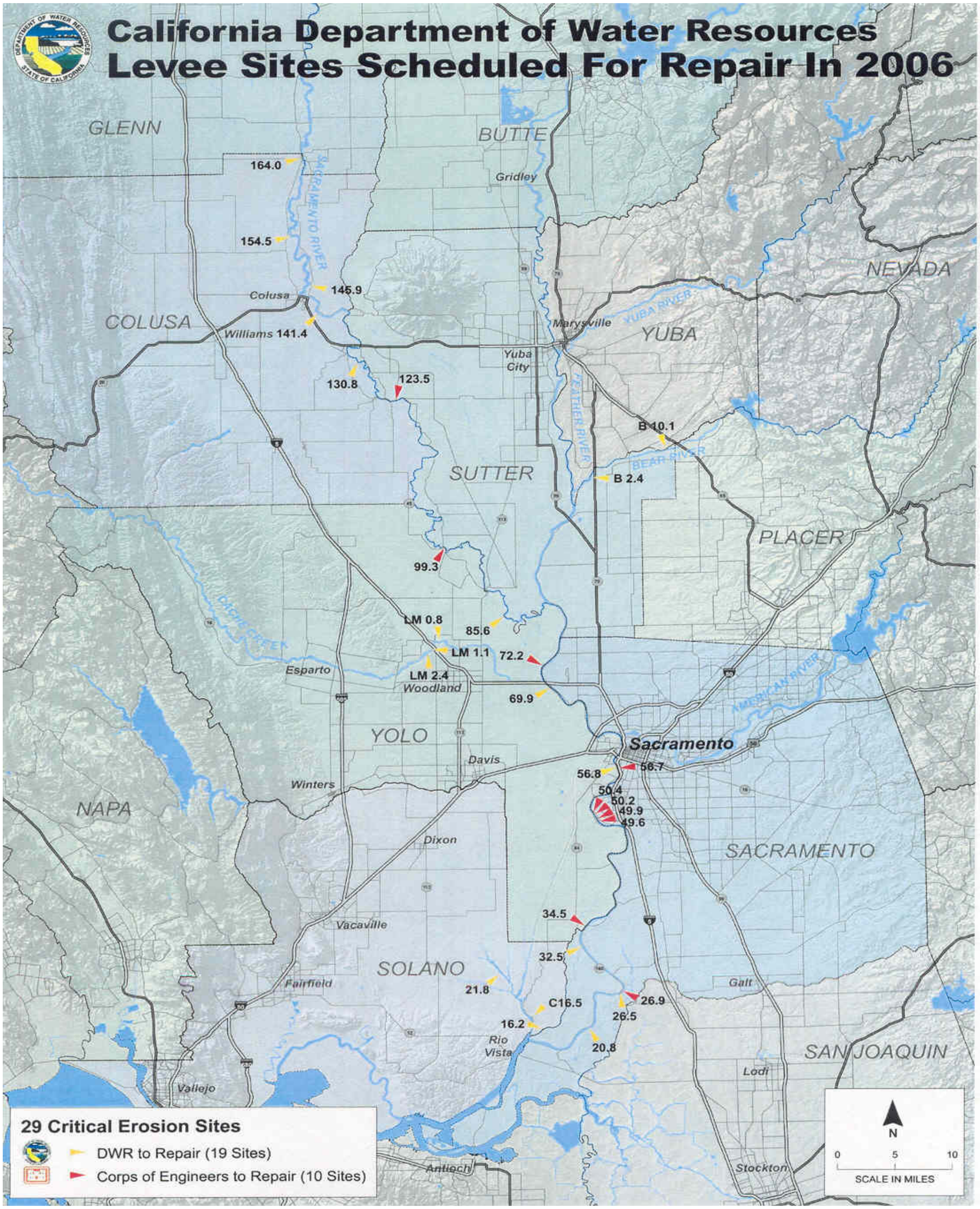

Figure 1. Map of critical levee erosion repair sites showing CDWR sites and Corps SRBPP sites. Three of the sites shown on the map, Cache Creek levee mile (LM) 0.8, 1.1, and 2.4, were the subject of a previous section 7 consultation and are not part of the proposed action.

Table 1. Project locations and engineered design features for Corps and CDWR critical levee emergency repair sites.

Project Lead	River or Slough	RM	Length (feet)	Total Project footprint (acres)	Area covered by Soil (acres)	Area below mean summer water elevation (acres)	Bench Width (feet)	Bench Area (acres)	Bench Elevations (ft NGVD)	IWM to be placed below mean summer water elevation (lf)	IWM to be placed above mean summer water elevation (lf)
Corps SRBPP	Sacramento	26.9 L	723	2.0	0.9	1.4	4	0.3	4.2	250	375
	Sacramento	34.5 R	786	1.8	1.0	1	4	0.3	4.9	257	390
	Sacramento	49.6 L	298	0.5	0.2	0.3	25	0.3	8 to 10	57	0
	Sacramento	49.9 L	268	0.5	0.2	0.3	30	0.3	8 to 10	70	0
	Sacramento	50.2 L	1,473	2.7	1.1	1.7	25	1.9	8 to 10	309	0
	Sacramento	50.4 L	329	0.6	0.4	0.3	35	0.3	8 to 10	95	30
	Sacramento	50.8 L	894	1.4	0.9	0.5	35	0.7	8 to 10	304	120
	Sacramento	51.5 L	888	2.2	1.0	1.3	35	1.5	8 to 10	231	140
	Sacramento	52.4 L	166	0.3	0.2	0.1	35	0.2	8 to 10	63	20
	Sacramento	53.1 L	470	0.3	0.1	0.2	25	0.3	8 to 10	48	20
	Sacramento	72.2 R	1,804	3.3	1.1	2.5	20	1.1	12 to 14	1,177	1,020
	Sacramento	99.3 R	491	1.1	0.8	0.7	20	0.2	24 to 32	160	240
	Sacramento	123.5 L	607	1.0	0.7	0.4	12	0.2	31 to 33	215	330
	Total	**13 sites**	**9,197**	**17.7**	**7.1**	**10.7**	**NA**	**7.1**	**NA**	**3,236**	**2,685**
CDWR	Cache Slough	16.5 L	360	0.6	0.3	0.2	10 to 19	0.1	5.0	0	0
	Cache Slough	21.8 R	2,340	3.6	2.0	2	15	1.1	4.6	***	***
	Steamboat Sl.	16.2 R	130	0.9	0.1	0.2	6	0.0	4.3	***	***
	Sacramento	20.8 L	600	0.8	0.2 *	0.2	15	0.2	4.6	***	***
	Sacramento	26.5 L	650	2	0.7	1.1	20	0.3	4 to 6	***	***
	Sacramento	32.5 R	2,250	6.1	1.3	3.8	20	1.0	5.0	***	***
	Sacramento	56.8 R	720	2	1.6	0.2	20	0.3	4 to 6, 18 to 20	288	288
	Sacramento	69.9 R	2,500	4.7	2.6	1.1	7	0.4	7.2	1,000	1,000
	Sacramento	85.6 R	1,055	2.8	0.8	0.6	7	0.2	15 to 19	422	422
	Sacramento	130.8 R	395	0.9	0	0.7	10	0.1	33 to 35, 48 to 50	158	158
	Sacramento	141.4 R	1,865	4.1	1.4	2.3	7	0.3	41.9	746	746
	Sacramento	145.9 L **	500	0.8	0.4	NA	NA	NA	NA	0	0
	Sacramento	154.5 R	710	1.3	0.8	0.6	10	0.2	53.8	284	284
	Sacramento	164 R	690	1.2	0.5	0.9	7	0.1	64.8	276	276
	Bear	2.4 L	1,339	0.8	1.1	1.4	7	0.2	37 to 41	536	536
	Bear	10.1 R	1,000	0.6	0.9	0.4	No bench	NA	NA	400	400
	Total	**16 sites**	**16,604**	**33.2**	**14.5**	**15.7**	**NA**	**4.5**	**NA**	**4,110**	**4,110**
	Grand Total	**29 sites**	**25,801**	**50.9**	**21.6**	**26.4**	**NA**	**11.6**	**NA**	**7,346**	**6,795**

* rock fill only
** Set back levee project. Project length not inlcuded in total and grand total.
***Any IWM removed during construction will be replaced, but additional IWM will not be included

Table 2. Project locations and engineered design features for September, 2006 amended project description.

Project Lead	River or Slough	RM	Length (feet)	Total Project footprint (acres)	Area covered by Soil (acres)	Area below mean summer water elevation (acres)	Bench Width (feet)	Bench Area (acres)	Bench Elevations (ft NGVD)	IWM to be placed below mean summer water elevation (lf)	IWM to be placed above mean summer water elevation (lf)
CDWR	Sacramento	43.3 R	750	1.4	1.0	1.3	6 to 10	0.4	2.7 and 10	300	300
	Sacramento	56.1 R	650	2.4	1.0	0.5	8 to 10	0.4	3.7 and 10	260	260
	Butte Creek	14.0 R	1,100	3.1	1.5	0.1	12	0.3	~ 181	440	440

B. Construction Schedule

Construction is proposed to begin on July 1, 2006. In-water construction will occur from July 1 through November 30, 2006. Construction on dry land may occur in months prior to or following this period. Placement of rock revetment, fill, and IWM would be completed during one construction season. Vegetation plantings would be installed and maintained during the same construction season and then maintained for an additional three years. Installation of container plantings at CDWR sites will occur during the spring of 2007.

C. Project Operation and Maintenance

Operation and Maintenance (O&M) activities that may be necessary to maintain the flood control and environmental values at the site include pruning and irrigation of planted vegetation for up to 3 years after revegetation is implemented, replacement vegetation planting, removal of invasive vegetation determined to be detrimental to the success of the project, monitoring of navigational hazards, and placement of fill and rock revetment if the site is damaged during high flow events or due to vandalism. Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive, as determined by the SAM. This approach will adaptively manage project conservation measures based on SAM modeling, monitoring, and professional judgment. Annual placement of the bank protection material would disturb no more than 300 feet per site per year, and require no more than 600 cubic yards of material per site, per year. If more than 300 feet, and 600 cubic yards per site need to be placed in any year, the operating and maintaining agency would consult separately with NMFS.

In coordination with Federal and State resource agencies, any in-water work would be conducted during appropriate time periods to avoid adverse impacts to fish. The current proposed in-water work window is July 1 to November 30 for any maintenance activities.

The Corps and CDWR will, within 12 months of the onset of construction of the proposed bank protection actions prepare a detailed O&M plan for the bank protection actions and any additional or off-site mitigation that may be required. The Corps shall at a minimum take yearly photos of the sites in two locations (*i.e.*, upstream, downstream) to document site performance.

The O&M plan shall ensure that riparian vegetation and anchored IWM are maintained and, pending the results of monitoring, adaptively managed to ensure their conservation value. If O&M activities identify new technologies to enhance habitat values for Federally listed fish species, they will be considered for wider application to other eroding sites in the SRBPP action area. Should the conservation measures fail, or be demonstrated to as harmful to any Federally listed species, the Corps may request NMFS to consider allowing the O&M practices to lapse or for conservation measures to be implemented using modified techniques or at other locations.

D. Proposed Compensation Measures

The Corps and CDWR anticipate that the projects will largely be self-compensating due to the extensive environmental features proposed to maintain, protect, or create habitat features beneficial to anadromous salmonids. However, the SAM analysis, or other evaluations may identify the need for further conservation measures, including off-site compensation. In this event, the following default compensation strategy will apply.

1. Compensation Strategy for the Proposed SRBPP Sites

Off-site mitigation will be implemented on the right (*i.e.*, north) bank of the American River 0.5 miles above the confluence with the Sacramento River. Access to the site is through Discovery Park. The project length is approximately 1,000 feet, the width varies from 0 to 300 feet measured from the edge of the river, and the project footprint is approximately 4 acres. Construction activities would be initiated during 2006 or 2007 dependent on cultural resource studies, and allowable construction windows.

This reach of the lower American River was substantially altered by the massive amounts of sediment deposited as a result of hydraulic mining in the upper watershed. The result is an elevated floodplain that has significantly altered the natural relationship between the river and the surrounding floodplain. The desirable vegetation communities are not reproducing and the floodplain is rarely available to fish.

The purpose of the project is to compensate for impacts to riparian and aquatic habitat caused by recent and future flood control projects on the Sacramento and American Rivers, including the Pocket sites and the Corps' additional 5 sites. The objectives are to restore natural habitats that will benefit special-status species including Federally listed fish, and several other plant and wildlife species. A primary component is to create juvenile salmonid habitat by constructing a vegetated bench with a range of elevations that will be inundated by typical winter and spring river stages. The range of elevations is designed to provide shallow (*i.e.*, 1 to 3 feet) of inundation in the target seasons and to create several planting zones related to hydrologic characteristics. The planting zones will provide a mixture of vegetation types to protect against erosion and provide cover for salmonids. The grading and planting plan is also designed to minimize predator species habitat and eliminate potential fish stranding in an existing closed depression in the terrace at the site. The project design is intended to be consistent with management objectives for Discovery Park, including those presented in the River Corridor Management Plan for the Lower American River.

The predominant project feature would be a large graded bench with an elevation range between 4 and 12 feet covering approximately a 2.0 acre area. The majority of this area is between elevation 5 and 9 feet. These elevations are designed to produce shallow inundation at average spring and winter river stages of 8 feet and 9.5 feet, respectively. The bench area grading includes two sloping depressions that are designed with inlets from the main channel to facilitate full drainage of the project site and reduce the risk of stranding fish during the transition to very low water river stages. Overall, the site will support a broad range of riparian habitat, providing a thick band of vegetation near the river and a less dense and varied palette over the rest of the project footprint. The design also includes the incorporation of IWM to provide enhanced fish cover along the bank and brush mattresses to control erosion. A distribution of relatively level benches at various elevations will provide shallow water for diverse salmonid rearing opportunities at target river stages.

Should the Corps determine that habitat restoration at American River mile 0.5 is not feasible, habitat restoration in the form of a set-back levee or other fluvial-function-restoring measure will be implemented. Any such set-back levee or other measure shall create a floodplain or erodible area that is no less than five times as large in areal extent as the bank area that exists now between the existing edge of water at the MSW and the existing projected levee section at MSW. Currently, this area is assumed to be the maximum potential extent of lateral river migration (*i.e.*, river functioning potential) that would be lost due to the proposed bank protection action. Other more accurate or representative methods of quantifying this river functioning potential and determining appropriate compensation may be developed in the future by the IWG for the SRBPP, before implementation of the off-site mitigation.

For any set-back levee or other measure implemented at a site which already has an existing, vegetated bench, SRA habitat, IWM, and other high-value aquatic habitat features, the IWG shall evaluate the relative degree of river functioning that would be restored at the mitigation site, and the USFWS and NMFS will use that information to determine the credit towards achieving the required river-functioning potential that will be granted for the set-back levee or other measure. The highest priority for off-site mitigation credit shall be granted for currently riprapped sites where high potential exists for restoration of IWM input, floodplain area, and fluvial functioning.

If the Corps fails to implement an off-site set-back levee or other measure within 1 year of riprapping the proposed action site, the additional temporal aquatic habitat losses incurred will be offset by increasing the original 5:1 mitigation ratio by an increment of 1. Thus, after 1 year the ratio increases to 6:1 and then increases each year thereafter by a factor of 1 (*i.e.*, 7:1 after 2 years, 8:1 after 3 years) until the set-back levee or other equivalent measure is implemented.

The 5:1 initial conservation ratio and additional annual increases are to be assessed on a site-by-site basis in the order each site is implemented, *i.e.*, the ratio first applies when a given site is first subject to work below the ordinary high water zone and concludes when a set-back levee or other measure has been implemented. The Corps will track the multiple time lines and acreages associated with these site-by-site conservation ratios and report them to the IWG for use in site selection.

The set-back levee or other measure's floodplain or erosion area shall include habitat features intended to maximize aquatic benefits for Federally listed fish species, including delta smelt and the three listed salmonids which occur in the SRBPP action area. Site design may be limited by various engineering and hydraulic constraints, but shall incorporate at least one of the following features: (1) a shallow, frequently-inundated, vegetated floodplain with an open canopy; (2) a less frequently inundated area including significant SRA, a more closed canopy, and high structural diversity; (3) significant occurrence of IWM recruitment; and (4) active erosion of banks.

Construction of the off-site set-back levee or other measure shall also result in the removal of at least as many lf of riprap from the newly-abandoned levee or bank as will have been placed via implementation of the proposed action at the Pocket Bank Protection Sites. If not, the Corps shall remove riprap from other locations until the necessary 1:1 rock removal criterion has been met. Non-Federal riprap placed subsequent to Clean Water Act implementation, but without a Corps 404 permit or associated mitigation may not be credited towards the 1:1 off-site rock removal. Such crediting could constitute abrogation of other regulatory responsibilities of the Corps and the resource agencies.

The set-back levee or other measure's engineered (*i.e.*, expected, anticipated) project life shall equal or exceed that of the design life of the Pocket Bank Protection Sites. The set-back levee or other measure's project life may be determined by hydraulic modeling or other means acceptable to the IWG for the SRBPP.

Implementation of the set-back levee or other measure must incorporate avoidance, minimization, and conservation measures sufficient to offset the adverse effects on all listed species under USFWS, NMFS, and CDFG jurisdiction. These impacts can be addressed by the IWG or by Corps staff during informal consultation. The set-back levees or other measures and removal of riprap may be constructed at any suitable location within the mainstream of the lower Sacramento River (*i.e.*, not tributary streams or sloughs) within the action area, as well as upstream to RM 243.0. The set-back levees or other measures and removal of riprap may occur, if consistent with Corps policy and all other regulatory considerations, on Federal and non-Federal levees and other sites.

2. <u>Compensation Strategy for the Proposed CDWR Sites</u>

Compensation, in the form of a set-back levee or other fluvial-function-restoring measure, will be implemented to the extent that the on-site features do not fully offset the project impacts. This will create a floodplain or erodible area that is no less than five times as large as the bank area that exists now between the existing edge of water at the MSW and the existing projected levee section at MSW. Currently, this area is assumed to be the maximum potential extent of lateral river migration (*i.e.*, river functioning potential) that will be lost as a result of the proposed levee repairs. Other more accurate or representative methods of quantifying this river functioning potential and determining appropriate compensation may be developed in the future before implementation of the off-site mitigation.

For any set-back levee or other measure implemented at a site that already has a vegetated bench, SRA habitat, IWM, and other high-value aquatic habitat features, the IWG will evaluate the relative degree of river functioning that will be restored at the mitigation site, and the USFWS and NMFS will use that information to determine the credit toward achieving the required river-functioning potential that will be granted for the set-back levee or other measure. The highest priority for off-site mitigation credit will be granted for currently rock-revetted sites where high potential exists for restoration of floodplain area, fluvial functioning, and IWM input.

The set-back levee's (or other measure's) floodplain or erosion area will include habitat features intended to maximize aquatic benefits for Federally listed fish species in the project area. Site design may be limited by various engineering and hydraulic constraints, but it will incorporate at least one of the following features: a shallow, frequently inundated, vegetated floodplain with an open canopy; a less frequently inundated area including significant SRA habitat, a more closed canopy, and high structural diversity; significant occurrence of IWM recruitment; and/or active erosion of banks.

The set-back levee's (or other measure's) engineered (expected or anticipated) project life will equal or exceed that of the design life of the repair. The set-back levee's (or other measure's) project life may be determined by hydraulic modeling or other means acceptable to the agencies. Implementation of the set-back levee or other measure must incorporate avoidance, minimization, and conservation measures sufficient to offset the adverse effects on all listed species under USFWS, NMFS, and CDFG jurisdiction. These impacts can be addressed by the IWG or by Corps staff during informal consultation. The set-back levees (or other measures) may be constructed, and rock revetment may be removed, at any suitable location within the mainstem of the lower Sacramento River (not tributary streams or sloughs) within the project area, as well as upstream to RM 243.0. The set-back levees (or other measures) and removal of rock revetment may occur, if consistent with Corps policy and all other regulatory considerations, on Federal and non-Federal levees and at other sites.

E. Additional Minimization and Conservation Measures that apply to SRBPP and CDWR Project Activities

The Corps and CDWR will incorporate the following additional measures into the project design, to help conserve and minimize impacts to listed species:

- Stockpiling of construction materials, including portable equipment, vehicles and supplies, including chemicals, shall be restricted to the designated construction staging areas and barges, exclusive of any riparian and wetlands areas.

- Erosion control measures (*i.e.*, Best Management Practices [BMPs]) that prevent soil or sediment from entering the river shall be placed, monitored for effectiveness, and maintained throughout the construction operations.

- All litter, debris, unused materials, equipment, and supplies shall be removed daily from any areas below the ordinary high water line daily and deposited at an appropriate disposal or storage site.

- Any spills of hazardous materials shall be cleaned up immediately and reported to the resource agencies within 24 hours. Any such spills, and the success of the efforts to clean them, shall also be reported in post-construction compliance reports.

- A representative shall be appointed by the Corps who shall be the point-of-contact for any Corps employee, or contractor, or contractor employee, who might incidentally take a living, or find a dead, injured, or entrapped threatened and endangered species during project construction and operations. This representative shall be identified to the employees and contractors during an all-employee education program conducted by the Corps relative to the various Federally listed species which may be encountered on the construction sites.

- If requested by the resource agencies, during or upon completion of construction activities, the Corps biologist/environmental manger or contractor shall accompany USFWS or NMFS personnel on an on-site, post-construction inspection tour to review project impacts and restoration success.

- The intakes for any water pumps needed for the construction process shall be screened to NMFS salmonid-screening specifications.

- A Corps representative shall work closely with the contractor(s) through all construction stages to ensure that any living riparian vegetation or IWM within "vegetation clearing zones," which can reasonably be avoided without compromising basic engineering design and safety, is avoided and left undisturbed to the extent feasible.

- Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive, as determined by the SAM. This approach will adaptively manage project conservation measures based on SAM modeling, monitoring, and professional judgment. Language providing such assurance(s) shall be provided to the resource agencies for review and concurrence before formal O&M documents are finalized by the Corps, and written evidence of acceptance of such assurance language by the local maintaining agency or district, shall be provided to the resource agencies.

- A study of the efficacy of integrated conservation measures (*i.e.*, plantings in riprap, planting bench, and anchored IWM) shall be instituted for a minimum of 5 years following construction. Focus of the study shall include, but not be limited to, IWM input and retention, sediment and organic matter retention and storage, habitat creation, and actual usage of the features by Federally listed and other fishes. Annual reports, and a final report deriving conclusions as to biological efficacy of the features, shall be provided to NMFS and the USFWS within 90 days of the study conclusion.

- The effectiveness of the set-back levee or other off-site mitigation measure, as well as that of any engineered mitigation technology, shall be evaluated through monitoring designed by the IWG. Findings of this monitoring may be used in future bank protection designs.

Furthermore, the Corps will seek to avoid and minimize effects to the extent feasible. There are a number of measures that will be applied to the entire project or specific aspects of the project and other measures that may be appropriate to implement at specific locations within the project footprint. Avoidance measures to be implemented during final design and construction may include, but are not limited to the following:

- Minimize effects by altering engineering design to avoid potential direct and indirect effects.

- Incorporate sensitive habitat information into project bid specifications.

- Fence sensitive habitats with orange construction fencing or similar material.

- Incorporate requirements for contractors to avoid identified sensitive habitats into project bid specifications.

- Minimize vegetation removal to the extent feasible, and leave as much existing IWM in place as possible, anchoring the IWM in place with rock.

- Perform no grubbing or contouring of the sites.

- Ensure all fill materials are placed with no excavation or movement of existing materials onsite.

- Ensure all construction activities; including clearing, pruning, and trimming of vegetation, is supervised by a qualified biologist to ensure these activities have a minimal effect on natural resources.

- If a cofferdam is needed during construction, it will be constructed by placing the sheet piles sequentially from the upstream to the downstream limits of the construction area (however, it is not anticipated at this time that a cofferdam will be needed). Prior to the closure of the cofferdam, seining will be conducted within the cofferdam with a small-mesh seine to direct fish out of the cofferdam and remove as many fish as possible. Upon completion of seining, exclusionary nets will be placed in the river to prevent fish from entering the cofferdam before the cofferdam is closed. When the cofferdam is partially dewatered, a final seining effort will be conducted within the cofferdam. Only low-flow pumps with screened intakes will be used during dewatering operations. If seining cannot rescue all listed species, a qualified fisheries biologist will use electrofishing to capture any remaining fish. All captured juvenile salmonids shall be released in the Sacramento River downstream of the construction area.

- Avoid direct and indirect effects on habitats containing or with a substantial possibility of containing listed terrestrial, wetland, and plant species to the extent feasible.

E. Monitoring

1. <u>Corps SRBPP Actions</u>

The Corps has developed a May, 2006, Mitigation and Monitoring Plan for Riparian, Aquatic, and Valley Elderberry Longhorn Beetle Habitat. The Corps proposes to apply this plan to the critical erosion repair sites, and other sites, as necessary for approximately 5 years following construction. Monitoring will begin in 2007, following construction and installation of integrated conservation measures. The monitoring plan will be incorporated into the O&M manual and implemented at all project sites. Elements of the monitoring plan include photographic documentation, riparian vegetation, SRA, IWM, shallow water habitat, instream vegetative cover, bank substrate size, and fish use of project sites using boat-mounted electrofishing.

Monitoring is necessary to ensure that the vegetated benches, IWM structures, and other conservation measures are functioning as projected by the SAM model. The Corps and the local sponsor shall submit a yearly report of monitoring results to the resource agencies by December 31 of each year. Monitoring is to be conducted until such time as the projected benefits of mitigation actions to Federally listed fish species can either be substantially confirmed or discounted. If integrated conservation measures fail to meet modeled SAM values in Appendix B, C, and D, specific remedial measures for each type of conservation measure (*i.e.*, riparian survival and growth, IWM, benches) and the level of effort applied to implement such measures will be determined based on the magnitude and the causes of failure. Potential remedial measures may include: (1) planting additional vegetation at the project site, (2) placing additional IWM at the project site, (3) extending the irrigation period, (4) planting additional plants at offsite locations, and (5) placing additional IWM at offsite locations.

2. <u>CDWR Actions</u>

CDWR submitted at May 24, 2006, Draft Mitigation Monitoring Plan for Riparian, Aquatic, and Valley Elderberyy Longhorn Beetle Habitat. The purpose of the plan is to summarize, organize, and integrate mitigation monitoring requirements for terrestrial and aquatic mitigation features at the 16 CDWR sites. The draft monitoring plan is similar to the Corps' plan except that it does not include a fishery monitoring component.

CDWR, with the assistance of the IWG and the ultimate approval of the resource agencies, also will develop a broader fisheries and aquatic ecosystem monitoring plan for the project area.

Larger-scale aquatic monitoring is necessary to ensure that the various experimental on-site mitigation features are functioning in a way that enhances habitat value and offsets adverse levee repair effects. Monitoring also is necessary to determine any adverse effects associated with the loss of river function and increased habitat fragmentation associated with the project. Monitoring will evaluate the effectiveness any restoration measures implemented to restore natural fluvial function (*i.e.*, set-back levees, restoration of eroding banks, *etc*.). The results of large-scale monitoring will be used to develop future minimization measures and conservation ratios with respect to Federally listed species and will help determine whether the emergency levee repair mitigation features require long-term maintenance or must be modified to reduce unforeseen adverse impacts on listed species and the ecosystems in which they occur.

F. Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area, for the purposes of this biological opinion includes the Sacramento River from RM 265 downstream to RM 20; the Bear River from RM 10.1 downstream to the confluence with the Feather River; Butte Creek from the RM 14.0 downstream to the confluence with the Feather River; Cache Slough from RM 21.8, downstream to the confluence with the Sacramento River, and Steamboat Slough from RM 16.2 downstream to the confluence with the Sacramento River. This area was selected because it represents the upstream and downstream extent of anticipated project actions, including potential off-site compensation actions.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionary significant units (ESU) or distinct population segments (DPS) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
endangered (June 28, 2005, 70 FR 37160)
Sacramento River winter-run Chinook salmon designated critical habitat
(June 16, 1993, 58 FR 33212)
Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
threatened (June 28, 2005, 70 FR 37160)
Central Valley spring-run Chinook salmon designated critical habitat
(September 2, 2005, 70 FR 52488)
Central Valley steelhead DPS (*Oncorhynchus mykiss*)
threatened (December 22, 2005)
Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)
Southern DPS of North American green sturgeon (*Acipenser medirostris*)
threatened (April 7, 2006, 70 FR 17386)

A. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook Salmon

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

Information on the migration rates of Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter *et al*. 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 km per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter *et al*. (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream (CALFED Science Program 2001) several days at a time. Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook, as described by Hughes (2004).

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). Upon emergence, fry swim or are displaced downstream (Healey 1991). Downstream movement of fry primarily occurs at night along the margins of the river. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in the stream for a period of time from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Meyer 1979, Healey 1980). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2001).

As juvenile Chinook salmon grow they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991). Catches of juvenile salmon in the Sacramento River near West Sacramento by the USFWS (1997) exhibited larger juvenile captures in the main channel and smaller sized fry along the margins. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration (Kjelson *et al*. 1982, Brandes and McLain, 2001).

Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al*. (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Summer *et al.* (2001) found rates ranging from approximately .5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healy 1982, Levy and Northcote 1981).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Healey 1991). Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San

Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallone Islands (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon were originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. NMFS reaffirmed the listing of Sacramento River winter-run Chinook salmon as endangered on June 28, 2005 (70 FR 37160).

Sacramento River winter-run Chinook salmon adults enter the Sacramento River basin between December and July; the peak occurring in March (Table 2, Yoshiyama *et al*. 1998, Moyle 2002). Spawning occurs primarily from mid April to mid August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and Red Bluff Diversion Dam (RBDD) (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3-years old.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Post-emergent fry disperse to the margins of the river, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all Sacramento River winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). Juvenile Sacramento River winter-run Chinook salmon occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (RM 57) (USFWS 2001). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 mm and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998).

Table 2. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[1]	Medium	Medium	High	Medium	Medium	Medium	Medium					Medium
Sac. River[2]	Medium	Medium	Medium	Medium	Medium	Medium					Medium	Medium

b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[3]	Low						Low / Medium	Medium	Medium	Medium	Medium	Medium
Sac. River @ Red Bluff[2]	Medium	Medium					Low	High	High	High	Medium	Medium
Sac. River @ Knights L.[4]	Medium	Medium	Medium	Low				Low	Low	Low	High	High
Lower Sac. River (seine)[5]	High	High	Medium	Low /					Low	Low	Medium	High
West Sac. River (trawl)[5]	Medium	High	High	High							Low	Medium

Source: [1]Yoshiama *et al*. 1998; Moyle 2002; [2]Myers *et al*. 1998; [3]Martin *et al*. 2001; [4]Snider and Titus 2000; [5]USFWS 2001

Relative Abundance: = High = Medium = Low

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stems primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives (RPAs) on temperature, flow, and operations of the Central Valley Project (CVP) and State Water Project (SWP); (2) Central Valley Regional Water Quality Control Board (Regional Board) decisions requiring compliance with Sacramento River water temperature objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CALFED) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn Colusa Irrigation District (GCID) diversion); (5) establishment of the CALFED Environmental Water Account (EWA); (6) Environmental Protection Agency actions to control acid mine runoff from Iron Mountain Mine; and, (7) ocean harvest restrictions implemented in 1995.

Historical Sacramento River winter-run Chinook salmon population estimates were as high as near 100,000 fish in the 1960s; however, populations monotonically declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,701), and 2005 (15,730) show a recent increase in the population size (CDFG Grandtab, February 2005, letter titled "Winter-run Chinook Salmon Escapement Estimates for 2005" from CDFG to NMFS, January 13, 2006). The 2005 run was the highest since the listing. Overall, abundance measures suggest that the abundance is increasing (Good *et al*. 2005). Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends. An agestructured density-independent model of spawning escapement by Botsford and Brittnacker in 1998 (as referenced in Good *et al*. 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of three consecutive spawning runs with fewer than 50 females (Good *et al*. 2005). Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population is improving, there is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good *et al*. 2005). Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the draft recovery goals established for the run (NMFS 1997, 1998) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for Sacramento River winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0. Recent trends in Sacramento River winter-run Chinook salmon abundance and cohort replacement remain positive, indicating some recovery since the listing. However, the population remains well below the recovery goals of the draft recovery plan, and is particularly susceptible to extinction because of the reduction of the genetic pool to one population. This is confirmed by Lindley *et al*. (2006) who found that although the extant population in the Sacramento River is at a moderate risk of extinction, the extensive extirpation of historical populations has placed the ESU at a high risk of extinction.

b. *Central Valley Spring-run Chinook Salmon*

CV spring-run Chinook salmon were listed as threatened on September 16, 1999 (50 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU as of June 28, 2005 (70 FR 37160).

Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 3, Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2004) indicates adult CV spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al*. 1998).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the year or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al*. 2004). Studies in Butte Creek (McReynolds *et al*. 2005, Ward *et al*. 2002, 2003) found the majority of CV spring-run Chinook salmon migrants to be fry occurring primarily during December, January and February; and that these movements appeared to be influenced by flow. Small numbers of CV spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer Creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer Creek juveniles typically exhibit a later young-of-the year migration and an earlier yearling migration (Lindley *et al*. 2004).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing (KL) occurs in December, and again in March and April; however, juveniles are observed between November and the end of May (Snider and Titus 2000).

Table 3. The temporal occurrence of adult (a) and juvenile (b) CV spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sac.River basin			Medium	Medium	High	High	Medium	Medium	Medium			
[3]Sac. River			Medium	Medium	Medium	Medium	Medium					
[4]Mill Creek			Low	Medium / High	High	High / Medium	Medium / Low	Low / –				
[4]Deer Creek			Low	Medium / High	High	High / Medium	Medium / –					
[4]Butte Creek		Medium	Medium	Medium	Medium	Medium	Medium					

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]Sac. River Tribs	Medium	Medium	Medium							Medium	High	High
[6]Upper Butte Creek	High	High	Medium	Medium	Medium	Low				Low	Low	High
[4]Mill, Deer, Butte Creeks	High	High	Medium	Medium	Medium	Low				Low	Low	Low
[3]Sac. River at RBDD	High	Low	Low	Low							High	High
[7]Sac. River at KL	Medium	Medium	High	High	Medium						Medium	High

Source:[1]Yoshiama *et al*. 1998; [2]Moyle 2002; [3]Myers *et al*. 1998; [4]Lindley *et al*. 2004; [5]CDFG 1998; [6]McReynolds *et al*. 2005; Ward *et al*. 2002, 2003; [7]Snider and Titus 2000

Relative Abundance: = High = Medium = Low

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally-spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al*. 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

CV spring-run Chinook salmon were once the most abundant run of salmon in the Central Valley (Campbell and Moyle 1992) and were found in both the Sacramento and San Joaquin drainages. More than 500,000 CV spring-run Chinook salmon were caught in the Sacramento-San Joaquin commercial fishery in 1883 alone (Yoshiyama *et al.* 1998). The San Joaquin populations were essentially extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Yoshiyama *et al.* 1998). Populations in the upper Sacramento, Feather, and Yuba Rivers were eliminated with the construction of major dams during the1950s and 1960s. Naturally spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 since between 2002 and 2005. Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the CV spring-run Chinook ESU as a whole because these streams contain the primary independent populations with the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remains well below estimates of historic abundance. Additionally, in 2003, high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter Columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

Several actions have been taken to improve habitat conditions for CV spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries;

and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally-spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist.

The time series of abundance for Mill, Deer, Butte, and Big Chico creeks CV spring-run Chinook salmon were updated through 2001 by Good *et al*. (2005). These time series show that the increases in population that started in the early 1990s have continued. During this period, there have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate. It appears that the three spring-run Chinook salmon populations in the Central Valley are growing (Good *et al*. 2005). All three spring-run Chinook salmon populations have signs of positive long- and short-term mean annual population growth rates. Although CV spring-run Chinook salmon have some of the highest population growth rates in the Central Valley, other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run Chinook salmon populations (Good *et al*. 2005). Because the CV spring-run Chinook salmon ESU is spatially confined to relatively few remaining streams, continues to display broad fluctuations in abundance, and a large proportion of the population (*i.e*., in Butte Creek) faces the risk of high mortality rates, the population remains at a moderate to high risk of extinction. This is confirmed by Lindley *et al*. (2006) who found that although existing independent populations in Deer, Mill, and Butte Creek are now at a low risk of extinction, the extensive extirpation of historical populations has placed the ESU at a higher risk of extinction.

2. Central Valley Steelhead

CV steelhead were listed as threatened under the ESA on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River basins in California's Central Valley. The Coleman National Fish Hatchery and FRH steelhead populations are now included in the listed population of steelhead (71 FR 834; these populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population). Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the American, Feather, and Yuba Rivers, and Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta.

Steelhead can be divided into two life history types, based on their State of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

CV steelhead generally leave the ocean from August through April (Busby *et al.* 1996), and spawn from December through April with peaks from January though March in small streams and tributaries where cool, well oxygenated water is available year-round (McEwan and Jackson 1996; Hallock *et al.* 1961) (Table 4). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

The female selects a site where there is good intergravel flow, then digs a redd and deposits eggs while an attendant male fertilizes them. The eggs are then covered with gravel when the female begins excavation of another redd just upstream. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51 °F. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating CV steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile CV steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002).

Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2000) also have verified these temporal findings based on analysis of captures at Chipps Island, Susuin Bay.

CV steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alterations from numerous water diversion projects) and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). Historic CV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Recent estimates from trawling data in the Delta indicate that approximately 100,000 to 300,000 smolts emigrate to the ocean per year representing approximately 3,600 female Central Valley steelhead spawners in the Central Valley basin (Good *et al*. 2005). This can be compared with McEwan's (2001) estimate of one million to two million spawners before 1850, and 40,000 spawners in the 1960s."

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, USFWS, pers. comm. 2002, as reported in Good *et al*. 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, CV steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Crammer and Associates Inc. 2000, 2001). It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999).

Table 4. The temporal occurrence of adult (a) and juvenile (b) CV steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,3]Sac. River												
[2,3]Sac R at Red Bluff												
[4]Mill, Deer Creeks												
[6]Sac R. at Fremont Weir												
[6]Sac R. at Fremont Weir												
[7]San Joaquin River												

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sacramento River												
[2,8]Sac. R at Knights Land												
[9]Sac. River @ KL												
[10]Chipps Island (wild)												
[8]Mossdale												
[11]Woodbridge Dam												
[12]Stan R. at Caswell												
[13]Sac R. at Hood												

Source: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock *et a*l. 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data; [8]CDFG unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2001; [11]Jones & Stokes 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980

Relative Abundance: = High = Medium = Low

Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff have prepared juvenile migrant Central Valley steelhead catch summaries on the San Joaquin River near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced Rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of Central Valley steelhead on the Tuolumne, Merced, and lower San Joaquin Rivers are severely depressed.

Lindley *et al*. (2003) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). The future of Central Valley steelhead is uncertain due to limited data concerning their status. Central Valley steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. This is confirmed by Lindley *et al*. (2006) who found that although there are insufficient data to assess the risk of any but a few populations, the available qualitative information does suggest that the ESU at a moderate to high risk of extinction.

3. Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2005, (71 FR 17757) and includes the North American green sturgeon population spawning in the Sacramento River and utilizing the Sacramento River, Delta and San Francisco Estuary.

North American green sturgeon are widely distributed along the Pacific Coast and have been documented offshore from Ensenada Mexico to the Bering Sea and found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002). In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon. Spawning has only been reported in one Asian river, the Tumin River in eastern Asia. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005, Erickson and Hightower 2006) of the continental shelf. During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco Estuary (Emmett *et* al 1991, Moyle *et al.* 1992). Recent acoustical tagging studies on the Rogue River (Erickson *et al*. 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 59 ^{o}F and 73 ^{o}F. When ambient temperatures in the river dropped in autumn and early winter (< 50 ^{o}F) and flows increased, fish moved downstream and into the ocean. In addition, Erickson *et al*. (2002) found individual green sturgeon adults spend up to six months in freshwater.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicates differences at least between the Klamath River and San Pablo Bay samples (Adams *et al*. 2002). The northern DPS includes all green sturgeon populations starting with the Eel River and extending northward. The Southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The Southern DPS of North American green sturgeon life cycle can be broken into four distinct phases based on developmental stage and habitat use (it was suggested by Nakamoto *et al.*, 1995, to break them into three parts); 1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age, 2) larvae and post-larvae less than 10 months of age, 3) juveniles less than or equal to 3 years of age, and 4) coastal migrant females between 3 and 13, and males between 3 and 9 years of age (Nakamoto *et al*. 1995).

New information regarding the migration and habitat use of the Southern DPS of North American green sturgeon has emerged. Lindley (2006) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears Southern DPS green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia. This information also agrees with the results of green sturgeon tagging studies completed by CDFG where they tagged a total of 233 green sturgeon in the San Pablo Estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of Oregon and Washington. Eight of the 12 recoveries were in the Columbia Estuary (CDFG 2002). In addition, recent analysis by Israel (2006a) indicates a substantial population of Southern DPS North American green sturgeon to be present in the Columbia estuary (50-80 percent).

Kelley *et al.* (2006) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature and the authors surmised they are related to resource availability (Kelley *et al*. 2006). Erickson *et al*. (2002) reported on movement and habitat use of green sturgeon in freshwater habitats in the Rogue River and found adult green sturgeon to hold at specific freshwater sites in the Rogue River for up to six months. Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al*. 2002). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al*. 2002). The authors surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205) and the documented presence of adults in the Sacramento River during the spring and summer months and the presence of larval green sturgeon in late summer in the lower Sacramento River indicating spawning ocurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Ray Beamesderfer, S.P. Cramer & Associates, Inc., pers. comm. 2006).

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, Adams *et al*. 2002, Jeffrey Stuart, NMFS, pers. comm. 2006). Adult sturgeon caught in Washington State waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

Based on the distribution of sturgeon eggs, larva, and juveniles in the Sacramento River, CDFG (2002) indicated that Southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City possibly to Keswick Dam. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (10 to 15 years based on sympatric white sturgeon sexual maturity (CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al*. 2001). Southern DPS of North American Green sturgeon adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July. Peak spawning is believed to occur between April and June (Table 5) and thought to occur in deep turbulent pools (Adams *et al*. 2002). Substrate is likely large cobble but can range from clean sand to bedrock (USFWS 2002). Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length.

After approximately 10 days, larvae begin feeding; growing rapidly and young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm fork length (CDFG 2002, USFWS 2002). The mean yearly total length of post-larval green sturgeon captured in rotary screw traps at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000 indicating they are approximately two weeks old. The mean yearly total length of post-larval green sturgeon captured in the Glen Colusa Irrigation District rotary screw trap, approximatley 30 miles downstream of RBDD ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, unpublished data) indicating they are approximately three weeks old (Van Eenennaam *et al*. 2001).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other Acipenseridae. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Exogenous feeding starts at approximately 14 days (23-25 mm)(Van Eenennaam *et al*. 2001). Larvae supplimented with live food in lab conditions exhibited significantly higher survival rates (Van Eenennaam *et al*. 2001). Kynard *et al*.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 46 ^{o}F, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al*. (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates juvenile Southern DPS North

American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al*. (2005).

Table 5. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2,3]Upper Sac. River			Medium	Medium / High	High	High / Medium	Medium	Medium	Medium	Medium	Medium	
[4]SF Bay Estuary				Medium	Medium	Medium	Medium	Medium	Medium	Medium		

(b) Larval and post-larval (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]RBDD, Sac River					Medium	High	High	Medium				
[5]GCID, Sac River					Medium	High	High	Medium	Low	Low		

(c) Juvenile (> 10 months old and ≤3 years old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
[6]Sac-SJ Delta	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
[5]Sac-SJ Delta				Medium	Medium	Medium	Medium	Medium	Medium	Medium		
[5]Suisun Bay	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Source: [1]USFWS 2002; [2]Moyle *et al*. 1992; [3]Adams *et al*. 2002 and NMFS 2005; [4]Kelley *et al*. 2006; [5]CDFG 2002; [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto *et al*. 1995

* Fish Facility salvage operations

Relative Abundance: = High = Medium = Low

Radtke (1966) examined 74 juvenile green sturgeon caught with gill net and otter trawl in the Delta. *Corophium* appeared to be the most important food of smaller green sturgeon and was the only item found in the eight smaller green sturgeon (190–390 mm) examined in the fall. All those examined in the spring and summer had eaten *Corophium,* which made up over half the volume of their diet during these seasons. *Neomysis awatschensis* was also utilized heavily during spring and summer. One fish examined in the spring had eaten shrimp that could not be identified. Growth is rapid as juveniles reach up to 300 mm the first year and over 600 mm in the first 2-3 years (Nakamoto *et al*. 1995). Little is known of the behavioral dynamics of these juveniles, such as habitat preference and water column usage; however, based on diet work reported above, the feeding morphology, juveniles are likely benthically oriented. Juveniles appear to spend one to three years in freshwater before they enter the ocean (Nakamoto *et al*. 1995).

Population abundance information concerning the Southern DPS of North American green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). CDFG (2002) utilizes a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and Glen Colusa Irrigation District on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of North American green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960’s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the portion of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and Southern DPS North American green sturgeon. Recent spawning population estimates using sibling based genetics by Israel (2006b) indicates a spawning population of 26 spawners in 2002, 18 in 2003, 30 in 2004, and 42 in 2005 above RBDD. Based on the length and estimated age of post-larvae captured at RBDD (approximately two weeks of age) and GCID (downstream; approximately three weeks of age), it appears the majority of Southern DPS North American green sturgeon are spawning above RBDD. Note there are many assumptions with this interpretation (*i.e*., equal sampling efficiency and distribution of post-larvae across channels) and this information should be considered cautiously.

There are at least two records of confirmed adult sturgeon observation in the Feather River (Beamesderfer *et al*. 2004); however, there are no observations of juvenile or larval sturgeon even prior to the 1960’s when Oroville Dam was built (NMFS 2005). There are also unconfirmed reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002).

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of CV spring-run Chinook salmon and CV steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning (Lindley *et al*. 2004) suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams (historical habitat characteristics, temperatures, and geology summarized). This spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pitt River system, and the McCloud River (NMFS 2005). Due to substantial habitat loss as well as existing threats to the Southern DPS of North American green sturgeon, it continues to remain at a moderate to high risk of extinction.

The freshwater habitat of North American green sturgeon in the Sacramento-San Joaquin drainage varies in function, depending on location. Spawning areas are currently limited to accessible upstream reaches of the Sacramento River. Preferred spawning habitats are thought to contain large cobble in deep cool pools with turbulent water (CDFG 2002, Moyle 2002).

Migratory corridors are downstream of the spawning areas and include the mainstem Sacramento River and the Estuary and Delta. These corridors allow the upstream passage of adults and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers which can include dams, unscreened or poorly screened diversions, and degraded water quality. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their 1 to 3 year residence in freshwater. Rearing habitat condition and function may be affected by variation in annual and seasonal flow and temperature characteristics.

B. Critical Habitat Condition and Function for Species' Conservation

The designated critical habitat for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat was designated for CV spring-run Chinook salmon and CV steelhead on September 2, 2005 (70 FR 52488). Critical habitat for CV spring-run Chinook salmon includes stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta. Critical Habitat for CV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; and, the San Joaquin River its tributaries, and the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (70 FR 52488). Critical habitat for CV spring-run Chinook salmon and steelhead is defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CV spring-run Chinook salmon and CV steelhead, and as physical habitat elements for Sacramento River winter-run Chinook salmon.

a. *Spawning Habitat*

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for Chinook salmon and steelhead is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam. CV spring-run Chinook salmon also spawn on the mainstem Sacramento River between RBDD and Keswick Dam and in tributaries such as Mill, Deer, and Butte Creeks. Spawning habitat for CV steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (*i.e*., above RBDD on the Sacramento River) throughout the Central Valley. Spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

b. *Freshwater Rearing Habitat*

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with set-back levees [*i.e.*, primarily located upstream of the City of Colusa]). However, the channelled, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Freshwater rearing habitat also has a high conservation value as the juvenile life stage of salmonids is dependant on the function of this habitat for successful survival and recruitment.

c. *Freshwater Migration Corridors*

Ideal freshwater migration corridors are free of obstruction with water quantity and quality conditions and contain natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility, survival and food supply. Migratory corridors are downstream of the spawning area and include the lower Sacramento River and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams, unscreened or poorly- screened diversions, and degraded water quality. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value.

d. *Estuarine Areas*

Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large wood, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas contain a high conservation value as they function as predator avoidance and as a transition to the ocean environment.

C. Factors Affecting the Species and Critical Habitat

1. <u>Chinook Salmon and Central Valley Steelhead</u>

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for west coast Chinook salmon (Myers *et al*. 1998) and steelhead (Busby *et al*. 1996). Also, the NMFS Biological Review Team (BRT) published a draft updated status review for west coast Chinook salmon and steelhead in November 2003 (NMFS 2003), and an additional updated and final draft in 2005 (Good *et al*. 2005). NMFS also assessed the factors for Chinook salmon and steelhead decline in supplemental documents (NMFS 1996, 1998). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212; 59 FR 440; 62 FR 24588; 62 FR 43937; 63 FR 13347; 64 FR 24049; 64 FR 50394; 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Program (CALFED 2000), and the Final Programmatic EIS for the CVPIA provide a summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley. The following general description of the status of species for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead is based on a summarization of these documents.

In general, the human activities that have affected listed anadromous salmonids and the PCE of their habitats consist of: (1) the present or threatened destruction, modification, or curtailement of habitat or range; (2) over-utilization; (3) disease or predation; and, (4) other natural and manmade factors.

a. *The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range*

(1) *Habitat Blockage*

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds resulting in the complete loss of substantial portions of spawning, rearing, and migration PCEs. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today. Yoshiyama *et al*. (1996) surmised that steelhead habitat loss was even greater than salmon loss, as steelhead migrated farther into drainages. The California Advisory Committee on Salmon and Steelhead Trout (1988) estimated that there has been a 95 percent reduction of Central Valley anadromous fish spawning habitat.

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid 1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River. On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon as well as CV steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967).

Changes in the thermal profiles and hydrographs of the Central Valley rivers have presumably subjected salmonids to strong selective forces (Slater 1963). The degree to which current life history traits reflect predevelopment characteristics is largely unknown, especially since most of the habitat degradation occurred before salmonid studies were undertaken late in the nineteenth century. Increased temperatures as a result of reservoir operations during winter and fall can affect emergence rates of Chinook salmon; thereby significantly altering the life history of a species (California Bay-Delta Authority 2005). Shifts in life history have the potential to seriously affect survival (California Bay-Delta Authority 2005).

Central Valley Chinook salmon exhibit an ocean-type life history; large numbers of juvenile Chinook salmon emigrate during the winter and spring (Kjelson *et al*. 1982, Gard 1995). High summer water temperatures in the lower Sacramento River (temperatures in the Delta can exceed 72 °F) create a thermal barrier to up- and downstream migration and may be partially responsible for the evolution of the fry migration life history (Kjelson *et al*. 1982).

The distribution of Sacramento River winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams allowed for spawning, egg incubation, and rearing in cold water (Slater 1963, Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento Rivers, and Hat and Battle Creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and, optimal stream flows in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle *et al.* 1989; NMFS 1997). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

The initial factors that led to the decline of CV spring-run Chinook salmon in the Central Valley also were related to the loss of upstream habitat behind impassable dams. Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures. The loss of upstream habitat had required CV spring-run Chinook salmon to less hospitable reaches below dams.

The loss of subsantiail habitat above dams also has resulted in decreased juvenile and adult steelhead survival during migration, and in many cases, had resulted in the dewatering and loss of important spawning and rearing habitats.

(2) *Water Diversion*

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in stream flows and diversions of water affect spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and IWM. More uniform flows year-round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement, caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. In addition, Brown and May (2000) found stream regulation to be associated with declines in benthic macroinvertebrate communities in Central Valley rivers. Macroinvertebrates are key prey species for salmonids.

Water withdrawals, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al*. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). Water temperatures in the Sacramento River have limited the survival of young salmon. Juvenile fall run Chinook salmon survival in the Sacramento River is also directly related with June streamflow and June and July delta outflow (Dettman *et al*. 1987).

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the central Delta via the Delta Cross Channel (DCC); (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and, (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.).

(3) ***Water Conveyance and Flood Control***

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As Mount (1995) indicates, there is an “underlying, fundamental conflict inherent in this channelization.” Natural rivers strive to achieve dynamic equilibrium to handle a watersheds supply of discharge and sediment (Mount 1995). The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects.

Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization, and riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000, Garland *et al*. 2002, Schmetterling *et al.* 2001). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970's, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960's and early 1970's it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996). However, it is now recognized that too much large woody debris was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody debris prior to 1980 had major, long-term negative effects on rearing habitats for salmonids in northern California (NMFS 1996). Areas that were subjected to this removal of large woody debris are still limited in the recovery of salmonid stocks; this limitation could be expected to persist for 50 to 100 years following removal of debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996). Large woody debris influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry. Downstream transport rates of sediment and organic matter are controlled in part by storage of this material behind large wood. Large wood affects the formation and distribution of habitat units, provides cover and complexity, and acts as a substrate for biological activity (NMFS 1996). Wood enters streams inhabited by salmonids either directly from adjacent riparian zones or from riparian zones in adjacent non-fish bearing tributaries. Removal of riparian vegetation and IWM from the streambank results in the loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting salmonid food supply.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is a primary cause of salmonid habitat degradation (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity, and affecting inter-gravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival.

(4) *Land Use Activities*

Land use activities such as agricultural conversion, and industrial and urban development continue to have large impacts on salmonid habitat in the Central Valley watershed, affecting spawning habitat, freshwater rearing habitat, freshwater migration corridors, estuarine areas, and nearshore marine area PCEs. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The CALFED Program (2000) estimated that wetter perimeter reductions in the Delta have decreased from between 25 and 45 percent since 1906. Historically, the San Francisco Estuary included more than 242,000 acres of tidally influenced bay-land habitats and tidal marsh and tidal flats accounted for 98 percent of bay-land habitats. Today only 70,000 acres of tidally influenced habitat remain (CALFED 2000). While historical uses of riparian areas (*e.g.*, wood cutting, clearing for agricultural uses) have substantially decreased, urbanization still poses a serious threat to remaining riparian areas. Riversides are desirable places to locate homes, businesses, and industry. Further, development within the floodplain results in vegetation removal, stream channelization, habitat instability, and point source (PS) and non-point source (NPS) pollution (NMFS 1996). The impacts of riparian vegetation and IWM loss are discussed in section *(3) Water Conveyance and Flood Control.*

In Pacific Northwest and California streams, habitat simplification has lead to a decrease in the diversity of anadromous salmonid species habitat (NMFS 1996). Habitat simplification may result from various land-use activities, including timber harvest, grazing, urbanization and agriculture. Reduction of wood in the stream channel, either from past or present activities, generally reduces pool quantity and quality, alters stream shading which can affect water temperature regimes and nutrient input, and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations. Removal of vegetation also can destabilize marginally stable slopes by increasing the subsurface water load, lowering root strength, and altering water flow patterns in the slope. Constricting channels with culverts, bridge approaches, and streamside roads can reduce stream meandering, partially constrict or channelize flows, reduce pool maintenance, and can preclude passage of anadromous salmonids. Diverse habitats support diverse species assemblages and communities. This diversity contributes to sustained production and provides stability for the entire ecosystem. Further, habitat diversity can also mediate biotic interactions such as competition and predation. Attributes of habitat diversity include a variety and range of hydraulic parameters, abundance and size of wood, and variety of bed substrate (NMFS 1996).

PS and NPS pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e*. concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (California Regional Water Quality Control Board-Central Valley Region 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (California Regional Water Quality Control Board-Central Valley Region 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

Past mining activities routinely resulted in the removal of spawning gravels from streams, channelization of streams from dredging activities, and leaching of toxic effluents into streams. Many of the effects of past mining operations still impact salmonid habitat today. Current mining practices include suction dredging, placer mining, lode mining and gravel mining. Present day mining practices are typically less intrusive than historic operations (hydraulic mining); however, adverse impacts to salmonid habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for buildings and highways.

Most aggregate is derived principally from pits in active floodplains, pits in inactive river terrace deposits, or directly from the active channel. Other sources include hard rock quarries and mining from deposits within reservoirs. Extraction sites located along or in active floodplains present particular problems for anadromous salmonids. Physical alteration of the stream channel may result in the destruction of existing riparian vegetation and the reduction of available area for seedling establishment (Stillwater Sciences 2002). As discussed previously, loss of vegetation impacts riparian and aquatic habitat by causing a loss of the temperature moderating effects of shade and cover, and habitat diversity. Extensive degradation may induce a decline in the alluvial water table, as the banks are effectively drained to a lowered level, affecting riparian vegetation and water supply (NMFS 1996). Altering the natural channel configuration will reduce salmonid habitat diversity by creating a wide, shallow channel lacking in the pools and cover necessary for all life stages of anadromous salmonids. In addition, waste products resulting from past and present mining activities, include cyanide (an agent used to extract gold from ore), copper, zinc, cadmium, mercury, asbestos, nickel, chromium, and lead.

b. *Over Utilization*

(1) *Ocean Commercial and Sport Harvest*

Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for Sacramento River winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of Sacramento River winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of Sacramento River winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent. In 2001 the CVI dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of other salmonids originating from the Central Valley (Good *et al*. 2005).

Ocean fisheries have affected the age structure of CV spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). Ocean harvest rates of CV spring-run Chinook salmon are thought to be a function of the CVI (Good *et al*. 2005). Harvest rates of CV spring-run Chinook salmon ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of Sacramento River winter-run Chinook salmon. The drop in the CVI in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of CV spring-run Chinook salmon. There is essentially no ocean harvest of steelhead.

(2) ***Inland Sport Harvest***

Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for Sacramento River winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult Sacramento River winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on Sacramento River winter-run Chinook salmon caused by recreational angling in freshwater. In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken CV spring-run Chinook salmon throughout the species' range. During the summer, holding adult CV spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of CV spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for Sacramento River winter-run Chinook salmon, provide some level of protection for spring-run fish (CDFG 1998).

There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally-produced adult steelhead; however, the total number of Central Valley steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al*. 2005).

c. *Disease and Predation*

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS

1996, 1998). Specific diseases such as bacterial kidney disease, C*eratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996, 1998). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that native fish tend to be less susceptible to pathogens than are hatchery reared fish. Salmonids may contract diseases that are spread through the water column (*i.e*., waterborne pathogens) as well as through interbreeding with infected hatchery fish.

A fish may be infected yet not be in a clinical disease State with reduced performance. Salmonids typically are infected with several pathogens during their life cycle. However, high infection levels (number of organisms per host) and stressful conditions (crowding in hatchery raceways, release from a hatchery into a riverine environment, high and low water temperatures, *etc*.) usually characterize the system before a disease State occurs in the fish.

Accelerated predation also may be a factor in the decline of Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, and to a lesser degree CV steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural river bank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall. In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. Sacramento squawfish (*Ptychocheilus grandis*) is a species native to the Sacramento River basin and has evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g.*, warm water, low-irregular flow, standing water, diversions) compared to its natural State and function 70 years ago, are more conducive to warm water species such as Sacramento squawfish and striped bass than native salmonids. Tucker *et al.* (1998) showed that predation during the summer months by Sacramento pikeminnow on juvenile salmonids jumped to 66 percent of total weight of stomach contents. Striped bass showed a strong preference for juvenile salmonids as prey during this study. This research also showed that the percent frequency of occurrence for juvenile salmonids and other fish were nearly equal in stomach contents. Tucker *et al.* (2003) showed the temporal distribution for these two predators in the RBDD area relative to the potential foraging impacts to juvenile salmonids. These researchers stated the importance of flow management to minimize the potential for condensing the concentration of forging areas.

USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally-eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Predation on juvenile salmon has increased as a result of water development activities which have created ideal habitats for predators and non-native species (NIS). Turbulent conditions near dam bypasses, turbine outfalls, water conveyances, and spillways disorient juvenile steelhead migrants and increase their avoidance response time, thus improving predator success. Increased exposure to predators has also resulted from reduced water flow through reservoirs; a condition which has increased juvenile travel time. Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the Fish Facilities, and the Susuin Marsh Salinity Control Gates (SMSCG). Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982); however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

Although the behavior of salmon and steelhead reduces the potential for any single predator to focus exclusively on them, predation by certain species can be seasonally and locally significant. Changes in predator and prey populations along with changes in the environment, both related and unrelated to development, have been shown to reshape the role of predation (Li *et al.* 1987). Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass (*Morone saxatilis*), of the aquatic fish predators, have the greatest potential to negatively affect the abundance of juvenile salmonids. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Catfish also have the potential to significantly affect the abundance of juvenile salmonids. Prickly (*Cottus asper*) and riffle (*C. gulosus*) sculpins, and larger salmonids also prey on juvenile salmonids (Hunter 1959; Patten 1962, 1971a, 1971b).

Avian predation on fish contributes to the loss of migrating juvenile salmonids by constraining natural and artificial production. Fish-eating birds that occur in the California Central Valley include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double- crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster's terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*) and bald eagles (*Haliaeetus leucocephalus*) (Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Mammals may be an important agent of mortality to salmonids in the California Central Valley. Predators such as river otters (*Lutra Canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonid include: badger (*Taxidea taxus*), bobcat (*Linx rufis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. Pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on salmonids (Spence *et al*. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) also prey on adult salmonids in the nearshore marine environment. Seal and sea lion predation is primarily in saltwater and estuarine environments, although they are known to travel well into freshwater after migrating fish. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable.

d. *Other Natural and Manmade Factors*

(1) *Climate Change*

The world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may raise by two or more degrees in the 21st century (IPCC, 2001). Much of that increase will likely occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding and permanent inundation of low-lying natural ecosystems (*e.g*., salt marsh, riverine, mud flats) affecting salmonid PCEs. Increased winter precipitation, decreased snow pack, permafrost degradation and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to over take native fish species and impact predator-prey relationships (Stachowicz *et al.* 2002, Peterson and Kitchell 2001).

An alarming prediction, is the fact that Sierra snow packs are expected to decrease with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon and CV steelhead) that must hold below the dam over the summer and fall periods.

(2) ***Artificial Propagation***

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels. For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of CV spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by over saturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally-produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally-produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally-spawning fish in the short term under specific scenarios, artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally-spawned populations at critically low abundance levels, as was the case with the Sacramento River winter-run Chinook salmon population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

(3) *Ocean Conditions*

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999). This phenomenon has been referred to as the Pacific Decadal Oscillation. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult life stage.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean (Southern Oscillation-ENSO). El Niño events occur when there is a decrease in the surface atmospheric pressure gradient from the normal-steady trade winds that blow across the ocean from east to west on both sides of the equator. There is a drop in pressure in the east off South America and a rise in the pressure in the western Pacific. The resulting decrease in the pressure gradient across the Pacific Ocean causes the easterly trade winds to relax, and even reverse in some years. When the trade winds weaken, sea level in the western Pacific Ocean drops, and a plume of warm sea water flows from west to east toward South America, eventually reaching the coast where it is reflected south and north along the continents.

El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes coastal currents and upwelling. Principal ecosystem alterations include decreased primary and secondary productivity and changes in prey and predator species distributions.

(4) ***Floods and Droughts***

During flood events, land disturbances resulting from logging, road construction, mining, urbanization, livestock grazing, agriculture, fire, and other uses may contribute sediment directly to streams or exacerbate sedimentation from natural erosive processes (California Advisory Committee on Salmon and Steelhead Trout 1988, NMFS 1996). Sedimentation of stream beds has been implicated as a principle cause of declining salmonid populations through-out their range. In addition to problems associated with sedimentation, flooding can cause scour and redeposition of spawning gravels in typically inaccessible areas. As streams and pools fill in with sediment, flood flow capacity is reduced. Such changes cause decreased stream stability and increased bank erosion, and subsequently exacerbate existing sedimentation problems (NMFS 1996). All of these sources contribute to the sedimentation of spawning gravels and filling of pools and estuaries used by all anadromous salmonids. Channel widening and loss of pool-riffle sequence due to aggradation has damaged spawning and rearing habitat of all salmonids.

Unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*e.g.*, Sacramento River winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall.

(5) *Non-native Invasives*

The extensive introduction of NIS have dramatically altered the biological relationships between and among salmonids and the natural communities that share rivers (NMFS 1998). As currently seen in the San Francisco Estuary, NIS can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco Estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants has certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

(6) *Ecosystem Restoration*

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for CV steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP Program have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Estuary in conjunction with tidal wetland restoration.

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward doubling the natural populations of select anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the Department of Interior's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for CV spring-run Chinook salmon and CV steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

The U.S. Environmental Protection Agency's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a State-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron Mountain Mine has shown measurable reductions since the early 1990s. Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

The California Department of Water Resource's Four Pumps Agreement Program has approved approximately $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreements inception in 1986. Four Pumps projects that benefit CV spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Estuary upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead.

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant, but un-quantified benefits to spring-run Chinook salmon attributed to CDFG.

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District, CDFG, and CDWR allows CDWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cfs, only 12 cfs has been developed to date. In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek. In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. CDWR, CDFG, and USFWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

2. <u>Southern Distinct Population Segment of North American Green Sturgeon</u>

The principal factors for the decline in the Southern DPS of North American green sturgeon are reviewed in the proposed listing notice (70 FR 17386) and status reviews (Adams *et al*. 2002, NMFS 2005), and primarily consist of: (1) the present or threatened destruction, modification, or curtailement of habitat or range; (2) poor water quality; 3) over-utilizatioon; 4) increased water temperatures, 5) NIS, (6), other natural and manmade factors.

a. *The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range*

(1) *Habitat Blockage and Range*

NMFS (2005) evaluated the ability to rank threats, but concluded that this was not possible due to the lack of information about their impact on the Southern DPS of North American green sturgeon; however, the principle threat considered is the impassible barriers, primarily Keswick and Shasta Dams on the Sacramento River and Feather River that likely block and prevent access to historic spawning habitat (NMFS 2005). Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams (historical habitat characteristics, temperature, and geology summarized by Lindley *et al*. 2004). This spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pitt River system, and the McCloud River (NMFS 2005). Green and white sturgeon adults have been observed periodically in the Feather River (Beamesderfer *et al*. 2004, USFWS 1995). There are no records of larval or juvenile white or green sturgeon;

however, there are reports that green sturgeon may reproduce in the Feather River during high flow years (CDFG 2002), but these are unconfirmed. No green sturgeon have been observed in the San Joaquin River; however, the presence of white sturgeon has been documented (USFWS 1995, Beamesderfer *et al*. 2004) making the presence of green sturgeon likely historically as the two species require similar habitat and their ranges overlap in the Sacramento River. In addition, the San Joaquin River had the largest spring-run Chinook salmon population in the Central Valley prior to the construction of Friant Dam (Yoshiyama *et al*. 2001) with escapements approaching 500,000 fish. Thus it is very possible, based on prior spring-run Chinook salmon distribution and habitat use of the San Joaquin River, that green sturgeon were extirpated from the San Joaquin Basin in a similar manner to spring-run. The loss of potential green sturgeon spawning habitat on the San Joaquin River also may have contributed to the overall decline of the Southern DPS of North American green sturgeon.

(2) *Water Diversion*

Based on the limited information regarding the size of green sturgeon larvae and nocturnal behavior during their development as well as the high number of diversions on the Sacramento River, it is reasonable to assume the potential threats of water diversions to green sturgeon are relatively high. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). At 5 days of age, larvae are approximately 22 mm in total length (Van Eenennaam *et al*. 2001). Based on this information, it is assumed larvae green sturgeon are suseptable to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6), and at a total length of approximatley 22 mm.

Herren and Kawasaki (2001) documented up to 431 diversions in the Sacramento River between Sacramento and Shasta Dam, most of which were unscreened and of the vertical or slant pump type. Entrainment information regarding larval and post-larval Southern DPS of North American green sturgeon is paltry, as the field identification of green sturgeon larvae is difficult. USFWS staff are working on identification techniques and are optimistic that green sturgeon greater than 40 mm can be identified in the field (Bill Poytress, USFWS, pers. comm. 2006). Captures reported by GCID are not identified to species but are asummed to primarily consist of green sturgeon as white sturgeon are known to spawn primarily between Knights Landing and Colusa (Schaffter 1997). Screens at GCID satisfy both the NMFS and CDFG screening criteria; however, the effectiveness of NMFS and CDFG screen criteria is unknown for sturgeon and there is a possibility that larval and post-larval green sturgeon are taken at GCID. Low numbers of Southern DPS of North American green sturgeon have also been identified and entrained at the Red Bluff Research Pumping Plant (Borthwick *et al*. 1999) and the efficacy of identification and enumeration of entrained post-larval green sturgeon is unknown at this location. The ACID diversion facility also may threaten larval and post-larval Southern DPS of North American green sturgeon as the upstream location of this facility exposes larvae and post-larval stages to entrainment. Information on the entrainment and impacts of this diversion on Southern DPS

North American green sturgeon are unknown. Information regarding the impacts of other small scale diversion indicated in Herren and Kawaski (2001) in the Sacramento River is unknown.

Presumably, as green sturegon juveniles grow, they become less suseptable to entrainment as their capacity to excape diversions improve. The majority of Southern DPS North American green sturgeon captured in the Delta and San Francisco Estuary are between 200 and 500 mm (CDFG 2002). Herren and Kawasaki (2001) inventoried water diversions in the Delta finding a total of 2,209 diversions of various types, only 0.7 percent of which were screened. The majority of these diversions were between 12 and 24 inches in diameter, likely with relatively little threat to larger juvenile sturgeon. The largest diversions recorded were those of the Fish Facilities in the south Delta. Based on historical data and captures at the Fish Facilities (CDFG 2002), it is reasonable to assume an unknown portion of the juvenile and adult population is excessively stressed, injured, harassed, or killed by the pumping plants.

Eight large diversions greater than 10 cfs and approximately 60 small diversions between 1-10 cfs exist on the Feather River between the Thermalito Afterbay outlet and the confluence with the Sacramento River (USFWS 1995). No studies to date have specifically addressed sturgeon entrainment on the Feather River; however, studies related to Chinook salmon entrainment at the Sutter Extension Water District's sunrise pumps found significant losses of juvenile salmon (USFWS 1995). Based on potential entrainment problems of green sturgeon elsewhere in the Central Valley and the presence of multiple screened and unscreened diversions in the Feather River, it is assumed that water diversions on the Feather River are a possible threat to juvenile Southern DPS North American green sturgeon.

A significant number of studies have been completed indicating that water exports are a limiting factor on native fish in the Delta (Kjelson *et al*. 1981, Kjelson *et al*. 1990, Meng *et al*. 1994, Meng and Moyle 1995, Meng and Matern 2001, Arthur *et al*. 1996, and Bennett and Moyle 1996. CDFG (1992) found a strong correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength in the Delta (many of the studies concerning sturgeon in the Delta involve the more abundant white sturgeon; however, the threats to green sturgeon are thought to be similar). Additional evidence supporting this relationship was also found when comparing annual production of young sturgeon in the San Francisco Estuary and salvage of young sturgeon at the Skinner Fish Facility between 1968 and 1987 during the months of April and May (CDFG 1992). This association of year class strength with outflow is also found in other anadromous fishes inhabiting the Estuary, such as striped bass, Chinook salmon, American shad, and longfin smelt (Stevens and Miller 1983). It is postulated that these increased outflows could improve survival by transporting dispersing larvae to areas of greater food availability, by dispersing larvae over a wide area of the rivers and San Francisco Estuary to take advantage of all available habitat, by quickly moving larvae downstream of any influence of water diversions in the Delta, or by enhancing productivity in the nursery area by increasing nutrient supply (CDFG 1992). Because of the young-of-year (YOY) flow correlation in the Delta exists, it is also assumed to be a factor in tributary flows.

In an effort to quantify the flow requirements necessary to double sturgeon populations on the Sacramento River, USFWS (1995) used the YOY year class estimates and corresponding flow data on the Sacramento River to identify years with good recruitment of white sturgeon. Year class estimates greater than two times the mean year class estimates were classified as good recruitment years. All other years were classified as poor recruitment years. Flow measured in the Sacramento River at Grimes and at Verona between February 1 and May 31 was then compared with corresponding YOY year class estimates between 1968 and 1990. All good recruitment years occurred in both wet or above-normal years and the flow from the good recruitment year with the lowest flow was used as a minimum flow standard (USFWS 1995). A minimum flow of 17,700 cfs between February 1 and May 31 at Grimes (RM 125) on the Sacramento River for wet and above normal water year types was recommended to provide adequate flows to allow adult migration from the San Francisco Estuary or ocean to spawning grounds, spawning, and downstream larval transport (USFWS 1995). Flows at or above 17,700 cfs occurred six times or 26 percent of the time. This flow was not reached during the six years between 1999 and 2004, though the 1999 and 2000 water years were close at 17,054 and 17,154 cfs respectively. Until additional instream flow studies relating to sturgeon are complete, these flow recommendations offer an approximate target. Additional flow recommendations as measured at Verona on the Sacramento River (RM 80) are also provided in USFWS 1995.

No specific studies of the effects of water diversions on the Southern DPS of North American green sturgeon have been completed to date; however, based on the considerable amount of evidence regarding the effects of diversions on other native fish, including white sturgeon, it is likely that water diversions also impact the Southern DPS of North American green sturgeon.

(3) *Water Conveyance*

The impacts of the development of the water conveyance system in the Central Valley have been reviewed in section C: *Factors Affecting the Species and Critical Habitat, Chinook Salmon and Central Valley Steelhead* of this biological option. As mentioned previously, the impacts of channelizing and bank riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006), as well as can adversely affect important ecosystem functions. In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting secondary consumer food supply (fish). Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile fish. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. Information on the lateral dispersion of green sturgeon across channel profiles is limited. Based on the benthic orientation of green sturgeon it is assumed habitat related impacts of channelization and riprapping would primarily consist of ecosystem related impacts, such as food source changes, and altered predator densities. The impacts of channelization and riprapping are though to affect larval, post-larval, juvenile and adult stages of Southern DPS North American green sturgeon, as they are all dependant upon the food web in freshwater for at least a portion of their life cycle.

(4) ***Migration Barriers***

Adult migration barriers to green sturgeon include structures such as the RBDD, ACID, Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC Gates. Major physical barriers to adult sturgeon migration on the mainstem Sacramento River are the RBDD and ACID diversion dam (USWFS 1995). Unimpeded migration past RBDD occurs when gates are raised between mid September and May for winter-run Chinook salmon passage measures. Fish ladders at RBDD are designed for salmonid passage and are used when dam gates are raised; however, improvements to the fish ladders may be possible if they can be designed to emulate the north ladder on Bonneville Dam on the Columbia River, which passes sturgeon successfully (CDFG 2002).

The Sacramento River Deep Water Ship Channel connects with the Sacramento River near the Cache Slough confluence above Rio Vista and provides a deepened and straightened channel to West Sacramento for commercial shipping purposes. A set of locks at the end of the channel at the connection with Sacramento River (in West Sacramento) "blocks the migration of all fish from the deep water ship channel back to the Sacramento River" (CDWR 2003).

Fremont Weir is located at the end of Yolo Bypass, a 40-mile long basin that functions as a flood control outlet. CDWR (2003) indicates that "sturgeon and sometimes salmon are attracted by high flows into the Yolo Bypass basin and then become concentrated behind Fremont Weir." They are then subject to heavy legal and illegal fishing pressure. In addition, field and anecdotal evidence shows that adult green sturgeon migrate up the Yolo Bypass up the Toe Drain in autumn and winter regardless of Fremont Weir spills (CDWR 2003). The weir is approximately 90 feet long and 5 feet high containing a poorly functioning fish ladder.

Numerous weirs and barriers in the Sutter Bypass known to be passage issues for Chinook salmon also could block sturgeon migration. Sturgeon are attracted to discharges into the toe drains of the Yolo Bypass and subsequently can't re-enter the Sacramento River. In addition, sturgeon attempt to pass over the Freemont weir during flood flows and become stranded behind the flashboards when the flows recede. Though most of these barriers have fish passage structures that work during certain flows (CDWR 2003), they are mostly designed for salmonid passage and would likely block sturgeon.

Upstream migrating adult Chinook salmon are known to utilize the DCC as a migratory pathway (Hallock *et al*. 1970). When the gates are open, Sacramento River water flows into the Mokelumne and San Joaquin Rivers providing migration cues. Attraction to this diverted water is thought to be one of the factors delaying and increasing the straying rate of Chinook salmon (McLaughlin and McLain 2004, CALFED Science Program 2001). In addition to increased travel distances, gate closures can completely block anadromous fish migrations forcing the fish to hold or retrace their routes through the Delta to reach spawning grounds upstream. DCC gate closures typically occur during the winter and early spring months when sturgeon are believed to migrate. Evidence suggests that female sturgeon reabsorb eggs and forgo spawning if prevented from reaching spawning grounds (USFWS 1995). In addition, potential spawning habitat is blocked. Habitat between RBDD and Jelly's Ferry Bridge (RM 267) contains swift current and pools over 20 feet deep as well as contains sand to sand-gravel mixtures found to be preferred by spawning white sturgeon (USFWS 1995, Schaffter 1997, CDFG 2002). Significant evidence exists that green sturgeon prefer similar spawning habitat, yet spawn above white sturgeon spawning areas on the Sacramento River (CDFG 2002).

Exact sturgeon spawning locations in Feather River are unknown; however, based on angler catches, most spawning is believed to occur downstream of Thermalito Afterbay and upstream of Cox's Spillway, just downstream of Gridley Bridge (USFWS 1995). The upstream migration barrier is likely a steep riffle 1 mile upstream of the Afterbay outlet with a depth of approximately 6 inches and length of 394 feet. Potential physical barriers to upstream migration include the rock dam associated with Sutter Extension Water District's sunrise pumps, shallow water caused by a head cut at Shanghai Bend, and several shallow riffles between the confluence of Honcut Creek upstream to the Thermalito Afterbay outlet (USFWS 1995). These structures are likely to present barriers to sturgeon during low flows blocking and or delaying migration to spawning habitat.

b. *Poor Water Quality*

PS and NPS pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e*. concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (California Regional Water Quality Control Board-Central Valley Region 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (California Regional Water Quality Control Board-Central Valley Region 1998) that contaminate drainage waters and destroy aquatic life necessary for steelhead survival (NMFS 1996).

Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, U.S. Bureau of Reclamation (USBR) District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). Discharge of rice irrigation water has caused mortality to both *Ceriodaphnia* and fathead minnows in the Sacramento River and it is believed that rice field discharges in May and June could affect sturgeon larvae survival (USFWS 1995). No specific information is available on contaminant loads or impacts in green sturgeon and the difference in distribution of green and white sturgeon (ocean migrants vs. estuarine inhabitants) probably makes green sturgeon less vulnerable than white sturgeon to bioaccumulation of contaminants found in the estuary (CDFG 2002).

High levels of trace elements can also decrease sturgeon early life-stage survival, causing abnormal development and high mortality in yolk-sac fry sturgeon at concentrations at the levels of parts per billion (Dettlaff *et al.* 1981, as referenced in USFWS 1995). Water discharges from Iron Mountain Mine, contaminated with heavy metals, have affected survival of fish downstream of Keswick Dam and storage limitations and limited availability of dilution flows cause downstream copper and zinc levels to exceed salmonid tolerances (USFWS 1995). Although the impact of trace elements on Southern DPS of North American green sturgeon production is not completely understood, negative impacts are suspected (USFWS 1995).

Organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Feather River (USFWS 1995). Feather River water collected at Verona on May 27 and June 5, 1987, resulted in a 50 and 60 percent mortality in *Ceriodaphnia* and fathead minnow bioassays, respectively. Similar effects were also found in the Feather River in 1988 and 1989 (Regional Water Quality Control Board, 1991, as cited in USFWS 1995). Toxic effects were attributed to organic contaminants in rice irrigation water released into Jack Slough and into Honcut Creek and Bear River to a lesser degree. Elevated levels of arsenic, chromium, copper, and mercury exceeding median international standards were found in various fish species in the Feather River between 1978 and 1987.

Water quality in the San Joaquin River has degraded significantly since the late 1940s (California Regional Water Quality Control Board [Regional Board] 2004). During this period, salt concentrations in the River, near Vernalis, have doubled. Concentrations of boron, selenium, molybdenum and other trace elements have also increased (Regional Board 2004). The extent of this problem as it relates to green sturgeon viability is unknown; however, it is clear that water quality on the San Joaquin River is potentially a problem for sturgeon (USFWS 1995).

c. *Over Utilization and Poaching*

Commercial harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries. Adams *et al*. (2002) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al*. (1991) indicated that an average of 4.7 to 15.9 tons of green sturgeon are landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appear to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al*. (2002) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). While no sport fishing captures can be attributed to California as all green sturgeon captured are captured incidentally, sport fishing in the Columbia River, Willapa Bay, and Grays Harbor captured from 22 to 553 fish per year between 1985 and 2001. Again, it appears sport fishing captures are dropping through time; however, it is not known if this is a result of abundance, changed fishing regulations, or other factors. Based on new research by

Israel (2006a) and past tagged fish returns reported by CDFG (2002), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population.

Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. Due to slot limits imposed on the sport fishery by the CDFG, only white sturgeon between 46 and 72 inches may be retained by sport fisherman with a daily bag limit of 1 fish in possession. Currently under emergency fishing regulations, all green sturgeon are to be returned to the water. CDFG (2002) indicates high sturgeon vulnerability to the fishery in areas where sturgeon are concentrated, such as the Delta to San Pablo Bay area in late winter and the upper Sacramento River during the spawning migration. In addition, the trophy status of white sturgeon and the consequent incentive for retaining oversize (>183 cm) fish is another impetus for active enforcement of sturgeon angling regulations (CDFG 2002).

Poaching rates on the Feather River are unknown; however, catches of sturgeon occur during all years, especially during wet years. There is no catch, effort, and stock size data precluding exploitation estimates (USFWS 1995). Areas just downstream of Thermalito Afterbay outlet and Cox's Spillway, and several barriers impeding migration may be areas of high adult mortality from increased fishing effort and poaching.

Poaching rates on the San Joaquin River are unknown; however, catches of sturgeon occur during all years, especially during wet years. There is no catch, effort, and stock size data precluding exploitation estimates. What is known, is that the small population of sturgeon inhabiting the San Joaquin River experiences heavy fishing pressure, particularly regarding illegal snagging and it may be more than the population can support (USFWS 1995).

d. *Increased Water Temperature*

Water temperatures greater than 63º F can increase sturgeon egg and larval mortality (Pacific States Marine Fisheries Commission 1992). Temperatures near RBDD on the Sacramento River historically occur within optimum ranges for sturgeon reproduction; however, temperatures downstream of RBDD, especially later in the spawning season, were reported to be frequently above 63º F (USFWS 1995). High temperatures in the Sacramento River during the February to June period no longer appear to be a concern as temperatures in the upper Sacramento River are actively managed for Sacramento River winter-run Chinook salmon, and the Shasta temperature curtain device installed at Shasta Dam in 1997 appears to maintain cool water conditions. A review of temperatures at RBDD during May and June between the years of 1995 and 2004 found no daily temperatures greater than 60 ºF (California Data Exchange Center preliminary data, RBDD daily water temperature data).

Approximately 5 miles downstream of Oroville Dam, water is diverted at the Thermalito Diversion Dam, into the Thermalito Power Canal, thence to the Thermalito Forebay and another powerhouse and finally into the Thermalito Afterbay. The Oroville-Thermalito Complex provides water conservation, hydroelectric power, recreation, flood control, and fisheries benefits. Feather River flows downstream of Oroville Dam to the Thermalito Diversion Dam is often referred to as the "low-flow" river section and maintains a constant 600 cfs. Thus, water temperatures downstream of the Thermalito Afterbay outlet are considerably higher than temperatures in the low-flow channel (USFWS 1995). It is likely that high water temperatures (greater than 63º F) may deleteriously affect sturgeon egg and larval development, especially for late-spawning fish in drier water years (USFWS 1995). CDFG (2002) also indicated water temperatures may be inadequate for spawning and egg incubation in the Feather River during many years as the result of releases of warmed water from Thermalito Afterbay. They believed that this may be one reason neither green nor white sturgeon are found in the river in low-flow years. It is not expected that water temperatures will become more unfavorable in the near future (CDFG 2002) and this temperature problem continues to be a threat.

The lack of flow in the San Joaquin River as a result of Friant Dam operations and agricultural return flows also contributes to higher temperatures in the mainstem San Joaquin River offering less water to keep temperatures cool for anadromous fish. Temperatures directly affect survival, growth rates, distribution, and development rates of anadromous fish. In addition, temperatures indirectly affect growth rate, distribution, and development rate of anadromous fish (Myrick and Cech 2004). Though these effects are difficult to measure, temperatures in the lower San Joaquin River continually exceed preferred temperatures for sturgeon migration and development during spring months. Optimal temperatures for egg and larval survival of white sturgeon are between 50 and 63º F and survival at early-developmental stages is severely reduced at temperatures greater than 68ºF (USFWS 1995). CDFG indicates water temperatures during May when Vernalis flow is less than 5,000 cfs were at levels causing chronic stress in juvenile Chinook salmon (Reynolds *et al*. 1993). Temperatures at Stevenson on the San Joaquin River near Merced River confluence on May 31 between 2000 and 2004 ranged from 77.2 to 81.7 ºF (California Data Exchange Center, preliminary data). Juvenile sturgeon are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. High water temperatures on the San Joaquin River and in the Delta are likely a threat to the Southern DPS of North American green sturgeon.

e. *Non-native Invasives*

Green sturgeon have most likely been impacted by NIS introductions resulting in changes in trophic interactions in the Delta. Many of the recent introductions of invertebrates have greatly affected the benthic fauna in the Delta and bays. CDFG (2002) reviewed many of the recent NIS introductions and the potential consequences to green sturgeon. Most notable species responsible for altering the trophic system of the Sacramento-San Joaquin Estuary include the overbite clam, the Chinese mitten crab, the introduced mysid shrimp *Acanthomysis bowmani*, and another introduced isopod, *Gammarus* sp. Likewise, introductions of invasive plant species such as the water hyacinth (*Eichhornia crassipes*) and *Egeria densa* have altered nearshore and shallow water habitat by raising temperatures and inhibiting access to shallow water habitat. *Egeria densa* forms thick “walls” along the margins of channels in the Delta. This growth prevents juvenile native fish from accessing their preferred shallow water habitat along the channel's edge. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. DO levels beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit. This level of infestation can produce barriers to anadromous fish migrations within the Delta. The introduction and spread of *Egeria* and water hyacinth have created the need for aquatic weed control programs that utilize herbicides targeting these species. The effects of these herbicides on green sturgeon are unknown and should be investigated.

f. *Other Natural and Manmade Factors*

(1) *Dredging*

Hydraulic dredging is a common practice in the Delta and San Francisco Estuary to allow commercial vessel traffic. Such dredging operations use a cutterhead dredge pulling water upwards through intake pipelines, past hydraulic pumps, and down outflow pipelines to disposal sites placing bottom oriented fish such as North American green sturgeon at risk. In addition, dredging operations can elevate toxics such as ammonia and copper (NMFS 2006). Other factors include bathymetry changes and acoustic impacts (NMFS 2006).

(2) *Climate Change*

The potential effects of climate change on the listed salmonids were discussed in the *Chinook Salmon and Central Valley Steelhead* section and primarily consist of altered ocean temperatures and stream flow patterns in the Central Valley. Changes in Pacific Ocean temperatures can alter predator prey relationships and affect migratory habitat of the Southern DPS of North American green sturgeon. Increases in rainfall and decreases in snow pack in the Sierra Nevada range will affect cold-water pool storage in reservoirs affecting river temperatures. As a result, the quantity and quality of water that may be available to the Southern DPS of North American green sturgeon will likely significantly decrease.

(3) *Conservation Measures*

The AFRP specifically applies the doubling effort toward Chinook salmon, CV steelhead, striped bass, and white and green sturgeon. Though most efforts of the AFRP have primarily focused on Chinook salmon as a result of their listing history and status, Southern DPS of North American green sturgeon may receive some unknown amount of benefit from these restoration efforts. For example, the acquisition of water for flow enhancement on tributaries to the Sacramento River, fish screening for the protection of Chinook salmon and CV steelhead, or riparian revegetation and instream restoration projects would likely have some ancillary benefits to the Southern DPS. The AFRP has also invested in one green sturgeon research project that has helped improve our understanding of the life history requirements and temporal patterns of the of the Southern DPS of North American green sturgeon.

Many notable beneficial actions have originated and been funded by the CALFED program including such projects as floodplain and instream restoration, riparian habitat protection, fish screening and passage projects, research regarding NIS and contaminants, restoration methods, and watershed stewardship and education and outreach programs. Prior Federal Register notices have reviewed the details of CVPIA and CALFED programs and potential benefits towards anadromous fish, particularly Chinook salmon and CV steelhead (50 CFR 33102). Projects potentially benefiting North American green sturgeon primarily consist of fish screen evaluation and construction projects, restoration evaluation and enhancement activities, contaminations studies, and DO investigations related to the San Joaquin River Deep Water Ship Channel. Two evaluation projects specifically addressed green sturgeon while the remaining projects primarily address listed salmonids and fishes of the area in general. The new information from research will be used to enhance our understanding of the risk factors affecting recovery thereby improving our ability to develop effective management measures.

IV. ENVIRONMENTAL BASELINE

The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02).

A. Status of the Species and Critical Habitat in the Action Area

1. <u>Status of the Species Within the Action Area</u>

The action area functions as a migratory corridor for adult Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead, and provides migration and rearing habitat for juveniles of these species. A large proportion of all Federally listed Central Valley salmonids are expected to utilize aquatic habitat within the action area. The action area also functions as a migratory and holding corridor for adult and rearing and migratory habitat for juvenile Southern DPS of North American green sturgeon.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon are currently only present in the Sacramento River below Keswick Dam, and are composed of a single breeding population (*Status of the Species and Critical Habitat* section). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of Sacramento River winter-run Chinook salmon was reviewed in the *Status of the Species and Critical Habitat* section. Adult Sacramento River winter-run Chinook salmon are expected to be present in the Sacramento River portion of the action area between November and June (Myers *et al*. 1998, Good *et al*. 2005) as they migrate to spawning grounds. Juvenile Sacramento River winter-run Chinook salmon migration patterns in the Sacramento River, Steamboat Slough, and Cache Slough portions of the action area can best be described by temporal migration characteristics found by the USFWS (2001) in beach seine captures along the lower Sacramento River between Sacramento and Princeton, and in the Delta south of Sacramento along the Sacramento River, and in nearby channels such as Steamboat and Georgiana sloughs. Because beach seining samples the shoreline rather than the center of the channel as is often the case in rotary screw traps and trawls, it is considered the most accurate sampling effort in predicting the nearshore presence of juvenile salmonids. In the Sacramento River, between Princeton and Sacramento, juveniles are expected between September and mid April, with highest densities between December and March (USFWS 2001). Delta captures were similar, but slightly later as they are downstream; juveniles are expected between November and mid April with highest densities between December and February. Rotary screw trap work at Knights Landing on the Sacramento River by Snider and Titus (2000) captured juveniles between August and April, with heaviest densities observed first during November and December, and second during January through March. The presence of juvenile Sacramento River winter-run Chinook salmon in Cache and Steamboat slough parts of the action area is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm. 2006). For example, the operation of the DCC gates affects Sacramento River flow entering Steamboat Slough increasing salmonid diversions into Steamboat Slough. In most cases, past catches of Sacramento River winter-run Chinook salmon juveniles in Cache and Steamboat sloughs have been relatively low (Jeff McLain, NMFS, pers. comm. 2006). In addition, a small number of juvenile Sacramento River winter-run Chinook salmon may be present at the Cache Slough site as a result of tidal-related movements as described by Vogel (2004). This will be dependant on tidal stage and migration characteristics. Sacramento River winter-run Chinook salmon do not exist in the Feather River, and Butte Creek watersheds, and are not expected to be present at the Butte Creek, or Bear River project sites.

b. *Central Valley Spring-run Chinook Salmon*

CV spring-run Chinook salmon populations currently spawn in the Sacramento River below Keswick Dam, the low-flow channel of the Feather River, and in Sacramento River tributaries including Mill, Deer, Antelope, and Butte Creeks (CDFG 1998). In Butte Creek, adult spawning and holding habitat is located several miles upstream from the action area. The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of CV spring-run Chinook salmon was reviewed in the *Status of the Species and Critical Habitat* section. Adult CV spring-run Chinook salmon are expected on the Sacramento River between March and July (Myers *et al*. 1998, Good *et al*. 2005). Peak presence is believed to be during February and March (CDFG 1998). In Butte Creek, adults may be present in the action area from February through June. In the Sacramento River, juveniles may begin migrating downstream almost immediately following emergence from the gravel with most emigration occurring from December through March (Moyle *et. al.* 1989, Vogel and Marine 1991). Snider and Titus (2000) observed that up to 69 percent of spring-run Chinook salmon emigrate during the first migration phase between November and early January. The remainder of the CV spring-run Chinook salmon emigrate during subsequent phases that extend into early June. The age structure of emigrating juveniles is comprised of young-of-the-year and yearlings. The exact composition of the age structure is not known, although populations from Mill and Deer Creek primarily emigrate as yearlings (Colleen Harvey-Arrison, CDFG, pers. comm. 2004), and populations from Butte Creek primarily emigrate during winter months as fry (Ward *et. al.* 2002). Younger juveniles are found closer to the shoreline than older individuals (Healey 1991). As is the case for Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in Cache and Steamboat slough parts of the action area is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm. 2006). In most cases, past catches of CV spring-run Chinook salmon juveniles in Cache and Steamboat sloughs have been relatively low (Jeff McLain, NMFS, pers. comm. 2006). In addition, a small number of juveniles may be present at the Cache Slough site as a result of tidal-related movements as described by Vogel (2004). This will be dependant on tidal stage and migration characteristics. Juvenile CV spring-run Chinook salmon may be present in the Bear Creek part of the action area during typical migration periods as this area is utilized by CV spring-run for non-natal rearing purposes (70 FR 52511).

c. *Central Valley Steelhead*

CV steelhead populations currently spawn in tributaries to the Sacramento and San Joaquin Rivers. The proportion of steelhead in this DPS that migrate through the action area is unknown. However, because of the relatively large amount of suitable habitat in the Sacramento River relative to the San Joaquin River, it is probably high. Adult steelhead may be present in all parts of the action area from June through March, with the peak occurring between August and October (Bailey 1954, Hallock *et al.* 1957). Highest abundance of adults and juveniles is expected in the Sacramento River part of the action area. Juvenile steelhead emigrate through the Sacramento River from late fall to spring. Snider and Titus (2000) observed that juvenile steelhead emigration primarily occurs between November and May at Knights Landing. The majority of juvenile steelhead emigrate as yearlings and are assumed to be primarily utilizing the center of the channel rather than the shoreline.

d. *Southern DPS of North American Green Sturgeon*

The spawning population of the Southern DPS of North American green sturgeon is currently restricted to the Sacramento River below Keswick Dam, and is composed of a single breeding population (*Status of the Species and Critical Habitat* section), thus the entire population of adults and juveniles must pass through the action area. Anecdotal evidence as well as habitat analysis by Lindley *et al*. (2004) indicates that the Southern DPS of North American green sturgeon may have been present on the Feather River (NMFS 2005) and the USFWS (1995) indicates they may be present on the Bear River, particularly during high water years. The presence of the Southern DPS of North American green sturgeon in Cache Slough is believed to be restricted to reaches below Cache Slough repair sites and near the entrance to the lower end of the Yolo Bypass (based on sturgeon presence at Fremont Weir).

A detailed assessment of the migration timing and life-history of the Southern DPS of North American green sturgeon was reviewed in the *Status of the Species and Critical Habitat* section. Adult Southern DPS of North American green sturgeon migrate upstream through the action area primarily between March and June (Adams *et al*. 2002). Larva and post-larvae are present on the lower Sacramento River between May and October, primarily during June and July (CDFG 2002). Small numbers of juvenile Southern DPS of North American green sturgeon have been captured at various locations on the Sacramento River as well in the Delta (in the action area downstream of Sacramento) during all months of the year (Interagency Ecological Program Database, Borthwick *et al*. 1999).

2. Status of Critical Habitat Within the Action Area

a. *Sacramento River winter-run Chinook salmon, Central Valley Steelhead and Central Valley spring-run Chinook Salmon*

The action area is within designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CV steelhead. Habitat requirements for these species are similar. The PCEs of salmonid habitat within the action area include: freshwater rearing habitat, freshwater migration corridors, and estuarine areas, containing adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food; riparian vegetation, space, and safe passage conditions. Habitat within the action area is primarily used as freshwater rearing and migration and as freshwater migration for adults. The condition and function of this habitat has been severely impaired through several factors discussed in the *Status of the Species and Habitat* section of this biological opinion. The result has been the reduction in quantity and quality of several essential elements of migration and rearing habitat required by juveniles to grow, and survive. In spite of the degraded condition of this habitat, the conservation value of the action area is high because its entire length is used for extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley.

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in streamflows and diversions of water affect freshwater rearing habitat and freshwater migration corridor PCEs in the action area. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (California Regional Water Quality Control Board-Central Valley Region 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (California Regional Water Quality Control Board-Central Valley Region 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area. Accelerated predation as a result of habitat changes in the action area such as the alteration of natural flow regimes and the installation of bank revetment structures such as dams, bridges, water diversions, piers and wharves are likely a factor in the decline of Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, and CV steelhead.

Within the action area, the freshwater rearing and migration PCEs have been transformed from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes and flooding. In the reach from Colusa downstream to Verona (RMs 143-80) levees are generally constructed near the edge of the river (USFWS 2000). Severe long-term riparian vegetation losses have occurred in this part of the Sacramento River, and there are large open gaps without the presence of important habitat features due to the high amount of riprap (USFWS 2000). Between Verona and Collinsville on the Sacramento River (RMs 80-0) the river is even more ecologically degraded having been impacted by bank protection and riprapping (USFWS 2000). Overall, more than half of the Sacramento Rivers banks in the lower 194 miles have been riprapped (USFWS 2000).

Jones and Stokes (2006a), Stillwater Sciences (2006), and CDWR (2006) estimated the approximate percent of linear coverage of existing (pre-project) revetment, riparian vegetation, and IWM at the levee repair sites. Overall, repair sites currently contain approximately between 44 and 70 percent revetment, 10 to 54 percent riparian vegetation, and 17 to 28 percent IWM (Table 6).

Table 6. Approximate pre-project percent revetment, percent riparian vegetation, and percent IWM in the action area. Percentages were averaged using pre-project values in Jones and Stokes (2006a), Stillwater Sciences (2006), and CDWR (2006).

% Revetment	% Riparian	% IWD
44-70	10-54	17-28

3. <u>Southern DPS of North American Green Sturgeon</u>

The majority of the action area is utilized by the Southern DPS of North American green sturgeon adults for holding and migration purposes. North American green sturgeon holding habitat consists of the bottoms of deep pools where velocities are lowest often in off-channel coves or low-gradient reaches of the main channel (Erickson *et al*. 2002). Erickson *et al*. (2002) also found many of these sites were also found close to sharp bends in the Rogue River.

The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to the Southern DPS of North American green sturgeon. It is assumed larval green sturgeon are susceptible to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6). Reduced flows in the action area likely affect year class strength of the Southern DPS of North American green sturgeon as increased flows have been found to improve year class strength. Adult migration barriers in the action area include the Sacramento Deep Water Ship Channel locks, Fremont Weir, and DCC Gates. These barriers can delay migration of Southern DPS North American green sturgeon affecting reproductive capacity and general health. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (California Regional Water Quality Control Board-Central Valley Region 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (California Regional Water Quality Control Board-Central Valley Region 1998) that contaminate drainage waters and destroy aquatic life necessary for green sturgeon survival (NMFS 1996). In addition, juvenile and adult green sturgeon are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area.

The transformation of the Sacramento River from a meandering waterway lined with dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation and IWM likely impacted potential prey items and species interaction that green sturgeon would experience while holding. The effects of channelization on upstream migration of green sturgeon are unknown.

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthically oriented (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. (2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

B. Factors Affecting the Species and Habitat in the Action Area

Because the size of the action area encompasses much of the applicable Sacramento River winter-run and CV spring-run Chinook salmon ESUs, and the CV steelhead DPS as well as the Southern DPS of North American green sturgeon, many of the factors affecting the species are discussed in the *Status of the Species and Habitat section* of this biological opinion. This section will focus on portions of the action area that most relevant to the general location of the proposed action.

1. <u>Sacramento River Winter-run Chinook Salmon and Central Valley Steelhead and Spring-run Chinook Salmon</u>

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks. Consequently, the mainstream of the river often remains too high and turbid to provide quality rearing habitat. High water temperatures also limit habitat availability for listed salmonids in the lower Sacramento River. High summer water temperatures in the lower Sacramento River can exceed 72 ^{o}F, and create a thermal barrier to the migration of adult and juvenile salmonids (Kjelson *et al*. 1982). In addition, water diversions, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months limiting the survival of juvenile salmonids (Reynolds *et al*. 1993). Impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, NIS, commercialization, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

Levee construction and bank protection have affected salmonid habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and SRA Cover. Individual bank protection sites typically range from a few hundred to a few thousand linear feet in length. Such bank protection generally results in two levels of impacts to the environment: 1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and 2) reach-level impacts which are the accumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat.

Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in IWM.

The use of rock armoring limits recruitment of IWM (*i.e.*, from non-riprapped areas), and greatly reduces, if not eliminates, the retention of IWM once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of IWM to become securely snagged and anchored by sediment. IWM tends to become only temporarily snagged along riprap, and generally moves downstream with subsequent high flows. Habitat value and ecological functioning aspects are thus greatly reduced, because wood needs to remain in place to generate maximum values to fish and wildlife (USFWS 2000). Recruitment of IWM is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (USFWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining nearshore refuge areas.

Most recently, the Corp's SRBPP constructed bank protection projects at RM 149 in 2001, and 56.7 in 2004. The RM 149 project included conservation measures recommended by NMFS and the USFWS to remove the jeopardizing effects of the action including constructing a set-back levee, or other conservation measures identified by the IWG that create or restore floodplain habitats, create additional riparian habitat, increase IWM recruitment, or improve the growth and survival of listed salmon and steelhead in the action area. The RM 56.7 project reaffirmed the commitment to implement conservation measures at RM 149, and described similar measures to minimize the effects of construction at RM 56.7. The RM 56.7 project also identified a timeline for implementing the conservation measures. At the time of this analysis, the conservation measures for these projects have not been implemented, but are on schedule to be completed within the timeframes stipulated in the project description for RM 56.7.

2. <u>Southern DPS of North American Green Sturgeon</u>

PS and NPS pollution resulting from agricultural discharge and urban and industrial development occurs in the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Habitat* section. Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, USBR District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). In addition, organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of green sturgeon. The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to the Southern DPS of North American green sturgeon. Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, NIS, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

The transformation of the Sacramento River from a meandering waterway lined with dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation and IWM likely impacted potential prey items and species interaction that green sturgeon would experience while holding. The effects of channelization on upstream migration of green sturgeon are unknown.

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthically oriented (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. (2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

C. Likelihood of Species Survival and Recovery in the Action Area

A majority of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead currently utilize the Sacramento River for rearing and migration. Some of these fish are expected to use off-channel estuarine areas in Cache and Steamboat sloughs, and non-natal areas within the lower Bear River for rearing and migration. These areas have high conservation value for the species because of their location, and the habitat features they provide that are essential to fulfilling certain life history requirements such as growth during outmigration. Therefore, improving population trends and ongoing habitat improvements to all of these rearing areas and migration corridors make it highly likely that these species will continue to survive and recover within the action area.

The entire population of Southern DPS of North American green sturgeon utilize the mainstem Sacramento River for spawning, rearing, and migration purposes. In addition, the Southern DPS of North American green sturgeon are known to occur in Delta areas including Cache Slough and Feather River. Habitats of the Sacramento River are very important for the Southern DPS of North American green sturgeon as they are the only know location of spawning (upstream) and the habitat features provide for essential life history requirements during larval rearing, juvenile and adult migration, and adult holding. Improvements in the action area will make it highly likely that these species will continue to survive and recover with the action area.

V. EFFECTS OF THE ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CV steelhead, their designated critical habitat, and threatened Southern DPS of North American green sturgeon.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this biological opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the

ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, we evaluate the available evidence to identify the direct and indirect physical, chemical, and biotic effects of proposed actions on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once we have identified the effects of an action, we evaluate the available evidence to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). We then use the evidence available to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

To evaluate the effects of the proposed action, NMFS examined proposed construction activities, O&M activities, habitat loss, and conservation measures, to identify likely impacts to listed anadromous salmonids within the action area based on the best available information.

The primary information used in this assessment includes fishery information previously described in the *Status of the Species* and *Environmental Baseline* sections of this biological opinion; studies and accounts of the impacts of water diversions and in-river construction activities on anadromous species; and documents prepared in support of the proposed action.

1. Information Available for the Assessment

The information used in this assessment includes fishery information previously described in the *Status of the Species* and *Environmental Baseline* sections of this biological opinion; studies and accounts of the impacts of riprapping and in-river construction activities on anadromous habitat and ecosystem function; and documents prepared in support of the proposed action, including the February 2006 BA for the SRBPP Pocket Sites (Jones and Stokes 2006a); the April 2006 Habitat Evaluation of the Pocket Bank Protection Sites using the SAM (Jones and Stokes 2006b); the May 2006 BA for the SRBPP Five Critical Erosion Sites at RMs 26.9, 34.5, 72.2, 99.3, and 123.5 (Corps 2006); the June 2006, revised BA for CDWR Critical Erosion Repair Projects (CDWR 2006); and the June 2006 Habitat Evaluation of the CDWR sites using the SAM (Jones and Stokes 2006c).

2. Assumptions Underlying this Assessment

B. Assessment

The assessment will consider the nature, duration, and extent of the proposed action relative to the migration timing, behavior, and habitat requirements of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon. Specifically, this assessment will consider the potential impacts related to construction and O&M activities, and will use the SAM model (Corps 2004) to assess species response to habitat modifications from proposed bank protection projects over a 50-year period. At this time, the SAM does not apply to green sturgeon. Therefore, long-term impacts to green sturgeon will be evaluated separately from impacts to anadromous salmonids.

The assessment of effects considers the potential occurrence of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, relative to the magnitude, timing, frequency, and duration of project activities. Effects of the proposed project on aquatic resources include both short- and long-term impacts. Short-term effects, which are related primarily to construction activities (*i.e.*, increased suspended sediment and turbidity), may last several hours to several weeks. O&M impacts are related to annual actions necessary to maintain project features and may occur for the life of the project (*i.e.*, 50 years). Long-term impacts may last months or years and generally involve physical alteration of the bank and riparian vegetation adjacent to the water's edge (*i.e.*, SRA habitat).

The project sites are downstream from the spawning habitat of Chinook salmon, steelhead, and the Southern DPS of North American green sturgeon. Therefore, no short- or long-term effects on spawning habitat are expected.

1. <u>Short-term Construction-related Impacts from SRBPP and CDWR Actions</u>

Construction would occur between July 1 and November 30. Placement of the bank protection material would disturb approximately 25,801 lf of river and slough bank and channel bottom. Specifically, construction would affect 20,632 lf of the Sacramento River, 2,330 lf of the Bear River, 1,100 feet of Butte Creek, 2,700 lf of Cache Slough, and 130 lf of Steamboat Slough. In-water construction activities, including the placement of rock revetment, could result in localized disturbance of habitat conditions and result in adverse effects to juvenile and adult fish.

Construction activities adjacent to or in the flowing waters of the Sacramento River will disturb soils and the riverbed and result in increased erosion, siltation, and sedimentation. Short-term increases in turbidity and suspended sediment may disrupt feeding activities of fish or result in temporary displacement from preferred habitats. Juvenile Chinook salmon, and steelhead could be directly affected because they depend on sight to feed. High concentrations of suspended sediment can also bury stream substrates that provide habitat for aquatic invertebrates, an important food source for juvenile salmonids and green sturgeon. Growth rates of fish could be reduced if suspended sediment and turbidity levels substantially exceed ambient levels for prolonged periods.

Numerous studies show that suspended sediment and turbidity levels moderately elevated above natural background values can result in non-lethal detrimental effects to salmonids. Suspended sediment affects salmonids by decreasing reproductive success, reducing feeding success and growth, causing avoidance of rearing habitats, and disrupting migration cues (Bash *et al.* 2001). Sigler *et al.* (1984) in Bjornn and Reiser (1991), found that prolonged turbidity between 25 and 50 Nephelometric Turbidity Unit (NTUs) reduced growth of juvenile coho salmon and steelhead. Macdonald *et al.* (1991) found that the ability of salmon to find and capture food is impaired at turbidities from 25 to 70 NTUs. Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 NTUs. Increased sediment delivery can also fill interstitial substrate spaces and reduce cover for juvenile fish (Platts *et. al.* 1979) and abundance and availability of aquatic invertebrates for food (Bjornn and Reiser 1991). We expect turbidity to affect Chinook salmon, steelhead in much the same way that it affects other salmonids, because of similar physiological and life history requirements between species.

Newcombe and Jensen (1996) believe that impacts on fish populations exposed to episodes of high suspended sediment may vary depending on the circumstance of the event. They also believe that wild fish may be less susceptible to direct and indirect effects of localized suspended sediment and turbidity increases because they are free to move elsewhere in the system and avoid sediment related effects. They emphasize that the severity of effects on salmonids depends not only on sediment concentration, but also on duration of exposure and the sensitivity of the affected life stage.

Suspended sediment from construction activities would increase turbidity at the project site and could continue downstream. Although Chinook salmon, steelhead, and green sturgeon are highly migratory and capable of moving freely throughout the action area, an increase in turbidity may injure fish by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Injury is caused when disrupting these behaviors increases the likelihood that individual fish will face increased competition for food and space, and experience reduced growth rates or possibly weight loss. Project-related turbidity increases may also affect the sheltering abilities of some fish and may decrease their likelihood of survival by increasing their susceptibility to predation.

Construction activities are expected to result in periodic turbidity levels that exceed 25 to 75 NTUs, and thus capable of affecting normal feeding and sheltering behavior. Based on observations during similar construction activities in the Sacramento River, turbidity plumes are not expected to extend across the Sacramento River, but rather the plume is expected to extend downstream from the site along the eastern side of the channel. Turbidity plumes will occur during daylight hours during in-water construction. At a maximum, these plumes are expected to be as wide as 100 feet, and extend downstream for up to 1000 feet. Once construction stops, water quality is expected to return to background levels within hours. Adherence to erosion control measures and BMPs such as use of silt fences, straw bales and straw wattles will minimize the amount of project-related sediment and minimize the potential for post-construction turbidity changes. Since project-related turbidity plumes will be limited to shoreline construction areas, NMFS expects that individual fish will mostly avoid the turbid areas of the river. For those fish that do not avoid the turbid water, exposure will be brief (*i.e.*, minutes to hours) and are not likely to cause injury or death from reduced growth, or physiological stress. Once fish migrate past the turbid water, normal feeding and migration behaviors are expected to resume. However, those fish that are exposed to project construction will encounter short-term (*i.e.*, minutes to hours) construction-related water quality changes that will cause injury or death to some individuals by increasing their susceptibility predation by temporarily disrupting normal behaviors, affecting sheltering abilities.

Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the Sacramento River as a result of spills or leakage from machinery or storage containers and injure or kill listed salmon, steelhead and sturgeon. These substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. Petroleum products also tend to form oily films on the water surface that can reduce DO levels available to aquatic organisms. NMFS expects that adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak. NMFS does not expect the project to result in water contamination that will injure or kill individual fish.

The extent of construction-related effects is dependant upon the timing of fish presence in the action area. Construction will occur from July through November 30. The majority of the winter-run Chinook salmon emigration in the action area occurs between November and January, but the peak is dependant upon initial flow increases of up to 20,000 cfs, which are most common from December through February. In-river construction activities will occur during low-flow conditions and will avoid primary winter-run migration periods. Therefore, NMFS expects that a relatively low, but unknown, abundance of Sacramento River winter-run Chinook salmon juveniles will be affected by project construction during November. Those fish that are exposed to project construction will encounter short-term (*i.e.*, minutes to hours) construction-related water quality changes that will cause injury or death by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors, affecting sheltering abilities.

Juvenile CV spring-run Chinook salmon and steelhead migration can begin as early as November, but similar to winter-run, the peak migration occurs during sustained high flow periods between December and March. NMFS expects that because in-water construction will be limited to low-flow conditions between July 1 and November 30, very few fish will be exposed to project activities. Implementation of BMPs and other on-site measures to minimize impacts to the aquatic environment will further reduce exposure to project-related disturbances. Those few, although unknown number, of individuals that are exposed to short-term construction-related water quality changes in November also may be injured or killed by an increased susceptibility to predation.

An overlap between the in-water work window and adult salmon and steelhead run timing also exists, although peak migration times for these species do not occur within the proposed inwater construction period. Sacramento River winter-run Chinook salmon are not expected to be present in the action area during the construction period, and will not be affected by construction. The latter portion of the adult CV spring-run Chinook salmon migration may overlap with construction during the first two weeks of July. The early portion of the steelhead run in September and early October and the latter portion of the run in late May and early June also will overlap with in-water work. Construction activities are not likely to injure or kill CV spring-run Chinook salmon and CV steelhead because these fish tend to utilize mid-channel, deep water habitats. Construction will be restricted to the channel edge, and would include implementation of the avoidance and minimization measures that will prevent impacts to these migration corridors.

Green sturgeon larvae and post-larvae are present in the action area between June and October with highest abundance during June and July (CDFG 2002), and remain in freshwater portions of the Delta for up to 10 months (Kynard *et al.* 2005). In addition, small numbers of juvenile sturgeon less than two years of age have been captured in the action area sporadically in the past (Jeff McLain, NMFS, pers. comm. 2006). Adult green sturgeon holding occurs in the Sacramento River in deep pools for up to nine months per year, primarily between March and November (USFWS 2002, Dave Vogel, Natural Resource Scientists, pers. comm. 2006). Short-term increases in turbidity and suspended sediment may disrupt feeding and migratory behavior activities of post-larvae, juvenile, and adult holding Southern DPS of North American green sturgeon. In-water activities could result in localized displacement and likely injury or mortality to individual green sturgeon that do not readily move away from the channel or nearshore areas directly affected by the project. Turbidity and sedimentation events are not expected to affect visual feeding success of green sturgeon, as they are not believed to utilize visual cues (Sillman *et al.* 2005); however, olfaction appears to be a key feeding mechanism and could be affected by such events. In addition, green sturgeon are known to immediately stop swimming and drift toward the substrate upon changes in light conditions (Sillman *et al.* 2005). Thus, the effects of sedimentation on light levels could illicit green sturgeon behavioral changes. Construction activities also may increase sediment, silt, and pollutants that could adversely kill or reduce production of food sources, such as aquatic invertebrates, for larval and juvenile green sturgeon. Since larvae and juveniles are reported to be photonegative (Deng *et al.* 2002) and nocturnal (Van Eenennaam *et al.* 2001), artificial lighting during the night which may be necessary occasionally may influence larval and juvenile green sturgeon behavior and movements, making them more susceptible to predation or other mortality measures. Because green sturgeon are primarily benthic and because the presence of juveniles and adults along the shoreline are not expected to be common, adverse effects including injury or death are not likely. In addition, the avoidance and minimization measures described above minimize potential turbidity and sedimentation impacts of in-water construction activities on larvae, post-larvae, juvenile, and adult Southern DPS of North American green sturgeon.

2. Effects of Project Operation and Maintenance

O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years) to maintain the flood control and environmental values of the site. Anticipated O&M actions include vegetation management and irrigation for up to three years, periodic rock placement to prevent or repair localized scouring, and periodic replacement or modification of IWM structures. Effects would be limited to the annual placement of the bank protection material that would disturb no more than 300 feet per site, and require the placement of up to 600 cubic yards of material. Impacts from O&M actions will be similar to the impacts of initial construction, and include injury or death from predation cause by turbidity changes that temporarily disrupt normal behaviors, and affect sheltering abilities. BMPs, summer in-water construction windows, and other minimization and avoidance measures will be implemented to reduce these effects to anadromous salmonids, green sturgeon, and their habitat.

3. Long Term Impacts as Projected by the SAM Model

The project is expected to result in long-term habitat modifications, including modifications to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. The modifications will affect PCEs of critical habitat including freshwater and estuarine rearing sites and migration corridors.

Long-term project effects include the alteration of river hydraulics and cover along approximately 25,801 lf of shoreline as a result of changes in bank configuration and structural features. These changes may affect the quantity and quality of nearshore habitat for juvenile Chinook salmon, steelhead and green sturgeon. Simple revetted slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit the deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators.

Removal of riparian vegetation and IWM from stream banks results in the temporal loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

Several project features were designed to address the need for ecologically functional shallow-water, floodplain habitat, riparian habitat, and cover in the confined reaches of the lower Sacramento River. The inclusion of a low bench, plantings of riparian vegetation, and placement of IWM will help restore habitat diversity. Irregular shorelines, riparian vegetation, IWM, and variability in bench elevations are expected to create low-velocity zones of deposition where sediment and organic material will be stored and made available to aquatic invertebrates and other decomposers. Vegetated low benches also will provide high-quality shallow water habitat for fish during winter and spring that will increase in value over time, as the vegetation becomes established.

Riparian vegetation along streams also provides shade, which incrementally moderates stream temperatures and prevents direct solar exposure of fish at shallow depths. The role of riparian shade in moderating stream temperatures is greatest on small streams and decreases with increasing stream size. Because of the large size of the Sacramento River, relative to its existing shoreline canopy, the effect of riparian vegetation in moderating water temperatures is minor, compared with the effects of reservoir operations, discharge, and meteorological conditions. Similarly, the effect of shade on the lower Bear River, Cache Slough, and Steamboat slough is minimal, primarily because of the low elevations and extremely warm summer air temperatures.

Most importantly, the removal of riparian vegetation reduces the potential recruitment of IWM and diverse fish habitat features at the project site and downstream. Minimizing the removal of existing riparian vegetation will reduce project impacts on IWM recruitment. However, for the purpose of the SAM assessment, it is assumed that up to 40 percent of the existing shoreline riparian canopy may be affected by project implementation. This is a very rough estimate, as effects to the riparian canopy will be necessary only to facilitate the placement of rock from a barge. Similarly, the SAM assessment assumes that up to 50 percent of the function of existing IWM will be lost to construction. Extensive revegetation, and installation of additional IWM is expected to reduce these impacts and losses of function.

a. *SAM Analysis*

Long-term project effects to critical habitat and species responses to such changes are measured in terms of the length and area of bank and channel bed disturbed by construction, and the quantity and quality of habitat as measured by the SAM. The SAM was developed by the Corps, in consultation with the NMFS, the USFWS, CDFG and CDWR, to address specific habitat assessment and regulatory needs for ongoing and future bank protection actions in the SRBPP action area. The SAM was designed to address a number of limitations associated with previous habitat assessment approaches and provide a tool to systematically evaluate the impacts and compensation requirements of bank protection projects based on the needs of listed fish species. A major advantage of the SAM is that it integrates species life history and flow-related variability in habitat quality and availability to generate species responses to project actions over time. Species responses represent an index of a species growth and survival based on a 30-day exposure to post project conditions at a variety of seasons and life-history stages, over the life of the project.

In general, the SAM quantifies habitat values in terms of a bank line or area-weighted species response index (WRI) that is calculated by combining habitat quality (*i.e.*, fish response indices) with quantity (*i.e.*, bank length or wetted area) for each season, target year, and relevant species/life stage. The fish response indices are derived from hypothesized relationships between key habitat variables and the responses of individual species and life stages. Rearing and outmigrating Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon responses to habitat variables tend to be similar, although seasonal presence and exposure may vary.

The response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival, growth, and/or reproduction. For a given site and scenario (*i.e.*, with or without project), the SAM uses these relationships to determine the response of individual species and life stages to the measured or predicted values of each variable for each season and target year, and then multiplies these values together to generate an overall species response index. This index can then multiplied by the area or linear feet of bank to which it applies to generate a weighted species response index, expressed as feet or square feet. The species response index provides a common metric that can be used to quantify habitat values over time, compare project alternatives to existing conditions, and evaluate the effectiveness of on-site and off-site compensation actions. Three separate SAM analyses were conducted: (1) the Habitat Evaluation of the Pocket Bank Protection Sites (Jones and Stokes 2006b); (2) the SAM data and results for RM 26.9, 34.5, 72.2, 99.3, and 123.5 conducted by Stillwater Sciences (Corps 2006), and (3) the Habitat Evaluation of the CDWR sites conducted by Jones and Stokes (2006c). These modeling efforts generated fish responses for each site in terms of area-weighted responses over a fifty-year period.

The SAM employs six habitat variables to characterize nearshore and floodplain habitats of listed fish species:

- Bank slope – This is the average bank slope along each average seasonal water surface elevation. Bank Slope is an indicator of shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. The relationship of bank slope to fish response is related to how variations in fish size and foraging strategies affect growth potential and expose various species and life stages to predation risk. For fry and smolts of each species, shallow water near the bank is considered to be high value because it provides refuge from predators and low velocity feeding and rearing habitat (Power 1987, Waite and Barnhart 1992, and Schlosser 1991). Smaller fish can avoid predation by piscivorous fish to some degree by selecting shallower water. Although larger fish (*i.e.*, smolts) typically use deeper water habitats, it is assumed that predation risk also increases. Adult life stages are not affected by the same predation as juveniles and tend to utilize deep, mid-channel habitat as migratory corridors. Therefore, adults are not expected to be sensitive to changes in bank slope.

- Floodplain availability – This is the ratio of wetted channel and floodplain area during the 2-year flood to the wetted channel area during average winter and spring flows. Floodplain availability is used as an indicator of seasonally flooded shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. Use of seasonally inundated flooded habitat is generally considered to increase growth of juvenile salmonids due to greater access to areas with high invertebrate productivity from flooded terrestrial matter (Sommer *et al.* 2001). Predation risk in seasonally flooded areas is expected to be less in seasonally inundated areas with large amounts of hiding cover and a lack of piscivorous fish. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in floodplain availability.

- Bank substrate size – This is measured as the median particle diameter of the bank (*i.e.*, D50) along each average seasonal water surface elevation. Bank substrate size is used as an indicator of juvenile refugia from predators, but also as an indicator of suitable predator habitat. Increased predator density has been observed at riprapped sites relative to natural banks at studies in the Sacramento River and the Delta (Michny and Deibel 1986, Michny 1989). Substrate size also is used as an indicator of food availability. The effects of substrate size on mortality risk are expected to be greatest at small grain sizes due to a lack of cover from avian and piscivorous fish predation. Predation risk is lower at intermediate sizes close to the size of the affected life stage because small interstitial spaces offer cover from predators. Predation risk is highest when grain sizes exceed the length of the affected life stage, because interstitial spaces are capable of providing effective cover for piscivorous fish species. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in bank substrate size.

- Instream structure – This is measured as the percent of shoreline coverage of IWM along each average seasonal water surface elevation. The value of instream structure to salmonids has been directly demonstrated by various studies. Instream structure is an indicator of juvenile refugia from predators (Michny and Hampton 1984, Michny and Deibel 1986). Instream structure is used as an indicator of food availability, feeding station availability, and as cover and resting habitat for adults. Instream structure provides high quality resting areas for adults and juveniles, cover from predation, and substrate for macroinvertebrate production (USFWS 2000, Lassettre and Harris 2001, Piegay 2002).

- Aquatic and submerged terrestrial vegetation – This is measured as the percent of shoreline coverage of aquatic or riparian vegetation along each average seasonal water surface elevation. Aquatic vegetation is used as an indicator of juvenile refugia from predators, and food availability. Rearing success is strongly affected by aquatic vegetation (Corps 2004). Biological response to aquatic vegetation is influenced by the potential for food production and cover to sensitive life stages. Because salmonid fry and juveniles are commonly found along shore in flooded vegetation (Cannon and Kennedy 2003) increases in aquatic and submerged terrestrial vegetation is expected to result in a positive salmonid response (*i.e.*, increased growth, reduced risk of predation). Adult salmonids are not expected to be sensitive to changes in aquatic or submerged terrestrial vegetation.

- Overhanging shade – This is measured as the percent of the shoreline coverage of shade along each average seasonal water surface elevation. The value of overhanging shade is an indicator of juvenile refugia from predators, and food availability. Numerous studies have shown the importance of overhanging shade to salmonids. Overhanging shade provides overhead cover, and allochthonous inputs of leaf litter and insects which provide food for juveniles. Michny and Hampton (1984), and Michny and Deibel (1986) juvenile salmonid abundance was highest in reaches of the Sacramento River with shaded riparian cover.

The SAM was used to quantify the responses of the target fish species and life stages to with-project conditions over a 50-year project period relative to the species and life stage responses under without-project (existing) conditions. The assessment followed the general steps outlined in the SAM Users Manual (Stillwater Sciences and Dean Ryan Consultants & Designers 2004). All computations were performed using the electronic calculation template provided by Stillwater Sciences. The results are presented in terms of WRIs for each target species, life stages, and season of occurrence in the project area. Input data includes site- and reach-scale data on existing bank slope, floodplain availability, bank substrate size, instream structure, aquatic and submerged aquatic vegetation, and overhanging shade at four average seasonal water surface elevations.

a. *Long-term Effects of SRBPP Actions on Anadromous Salmonids*

SAM model results for the Corps' Pocket sites (Jones and Stokes 2006b) are summarized in Appendix B, Figures 1 and 2, and Tables 1 and 2. SAM model results for the Corps' additional five sites (Corps 2006) are shown in Appendix C, Tables 1 through 5. Results are summarized for Chinook salmon and CV steelhead at average seasonal water surface water surface elevations. The model accounts for variability in flow by generating results at four different average water surface elevations. Also, model input values are taken at a range of elevations for up to three feet below the average seasonal water surface. Although the model focuses on a discrete average water surface elevation, seasonal variability of average flows is accounted for in the project designs because project features, and conservation measures (*i.e.*, benches, vegetation, and IWM) are placed at variable elevations.

The Pocket site assessment assumed that anadromous salmonids in the action area would not occur at summer flows and, accordingly, did not report any results for that season. Additionally, the Pocket site SAM assessment considered impacts to Chinook salmon and steelhead at various juvenile life stages and seasons, but did not assess impacts to adults, and did not distinguish between Chinook salmon species because it was assumed that adults occupied the mid-channel habitats and were unlikely to be affected by shoreline construction, and because winter-run Chinook salmon and CV spring-run Chinook salmon would exhibit similar responses to bank protection. The SAM assessment for the five additional sites reported results for adult life stages, summer water surface elevations, and reported different results for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and steelhead.

(1) *Adult Migration*

Adult Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon migrate up the Sacramento River from December through July, and CV steelhead may migrate upstream from September through May. These fish use the river channel at the project sites as a migration pathway to upstream spawning habitat. Long-term changes in nearshore habitat are expected to have negligible effects on adults because adult Chinook salmon generally use deep, mid-channel habitat during migration. SAM results from the Corps' additional five sites at RMs 26.9, 34.5, 72.2, 99.3, and 123.5 show a positive response for adults. This primarily is due to the installation of IWM, which may provide cover and refugia to individual fish during upstream migration. NMFS expects that this positive response also would occur at the Pocket sites from similar additions of IWM.

(2) *Juvenile Rearing and Migration*

Rearing and emigrating juveniles and smolts may occur at the project sites during the fall, winter, and spring. Downstream movement of substantial numbers of juvenile Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon appears to be triggered by storm events and the resulting high flow and turbidity, with the peak outmigration period for Sacramento River winter-run Chinook salmon typically occurring in from November through January, and the period for CV spring-run Chinook salmon occurring from December through May. Juveniles and smolts are most likely to occur at the project sites during their downstream migration to the ocean, which may begin as early as December and peaks from January to May.

The construction of seasonally inundated vegetated benches, vegetated wetland trenches, and the retention and/or placement of riparian vegetation, and IWM at all project sites are designed to benefit juvenile Chinook salmon and steelhead by increasing the availability (*i.e.*, habitat area), accessibility (*i.e.*, frequency of inundation), and quality (*i.e.*, shallow water and in stream cover) of nearshore aquatic habitat and SRA habitat relative to current conditions. Because of these design features, the project is expected to provide an overall long-term increase over current conditions in the quantity and quality of estuarine and freshwater rearing sites and migration corridors for juvenile Chinook salmon and steelhead. However, some short- and long-term impacts will occur. Numerical SAM results for the Pocket site projects (*i.e.*, RMs 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, and 53.1) are shown in Appendix B, Figures 1 and 2, and Tables 1 and 2. Results are shown for each species, at each average seasonal water surface elevation, over a 50 year period. Numerical results for the additional five SRBPP sites at RMs 26.9, 34.5, 72.2, 99.3, and 123.5 are shown in Appendix C, Tables 1 through 5.

At RMs 99.3, and 123.5, the SAM results show increases in habitat value for all life stages of Chinook salmon and steelhead, under all flow conditions, for the life of the project. Results are almost all positive at RMs 26.9 and 34. At 26.9, the only deficits occur for steelhead smolts, at winter water surface elevations during the first year after construction. At RM 34, deficits occur for steelhead smolts at spring water surface elevations for 15 years after construction. The increases primarily reflect the positive responses of juveniles to increases in the availability of shallow-water habitat and extent of flooded vegetation on the constructed bench. The addition of IWM also contributes to these increases. All sites would exhibit short-term reductions of instream cover and shade associated with the damage or removal of some riparian vegetation and IWM along the winter-spring shoreline, but these reductions would be completely offset by an immediate increase in the availability of shallow-water habitat following construction. Juvenile fish that are exposed to these sites are expected to experience improved growth and survival conditions compared to existing conditions.

Projects at RMs 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, and 53.1 would result in a long-term deficit in nearshore habitat values at fall water surface elevations due to the damage or removal of some riparian vegetation and IWM along the winter-spring shorelines, and loss of fall shallow-water habitat. These deficits appear to be offset by significant long-term increases in SAM values at winter and spring water surface elevations. Area-weighted response indices at fall flow conditions would recover slightly and stabilize because of increases in shade along the average fall shoreline, but generally remain negative for the life of the project. At RM 49.6 and RM 51.5, initial losses of vegetative cover and IWM would be sufficient to cause a net deficit at winter and spring water surface elevations, for the first 10 to 15 years of the project. During the years and flow conditions where there is a deficit in SAM values, individual fish migrating during the fall (*i.e.*, November) would be injured or killed by reduced growth conditions and increased predation.

The shallow off-channel habitat created by the vegetated wetland trenches at RMs 26.9 and 34.5 could provide habitat for predatory fish because they will be inundated year round. However, the shallow depth of these areas during summer and fall flows, probably will limit the number and size of predatory fish. Salmon and steelhead using these areas may be subject to some predation, but also will benefit from improved growth conditions during higher flows when water temperatures are low and predators are less active.

At RM 72.2, reductions in area-weighted response indices for Chinook salmon and steelhead juvenile rearing and smolt migration occur at fall and spring water surface elevations for the life of the project. The deficits at RM 72.2 reflect the reduction in nearshore habitat value due to impacts to a larger amount of riparian vegetation during construction than at other sites.

Overall, the project results in SAM deficits for juvenile and smolt Chinook salmon at fall water surface elevations, and increases for juvenile and smolt Chinook salmon and steelhead at winter and spring water surface elevations, (Appendix B, Figures 1 and 2). Total, combined values for fall, winter, and spring water surface elevations are negative for juvenile and smolt Chinook salmon during the first year, but increase substantially above existing baseline conditions by year 5, with increases in habitat value increasing for the life of the project. Long-term increases in Chinook salmon and steelhead SAM values primarily reflect the positive response of juveniles to an increase in the availability of shallow-water habitat and extent of flooded vegetation on the constructed bench. In summary, this means that for many projects, habitat impacts will result in reduced growth and survival conditions for juvenile and smolt Chinook salmon at fall water surface elevations for the life of the project, and substantial increases above baseline conditions at winter and spring water surface elevations. Fall deficits are expected to affect relatively few fish, since the majority of rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead rearing and emigration occurs during periods of higher flow that are more accurately represented by overall positive SAM values at average winter and spring water surface elevations.

b. *Long-term Effects of SRBPP Actions on the Southern DPS of North American Green Sturgeon*

(1) ***Adult Migration and Holding***

Adult Southern DPS of North American green sturgeon move upstream through the project sites between March and November. Long-term changes in nearshore habitat are expected to have negligible effects on adults because adult sturgeon use deep, mid-channel habitat during migration. The long-term effects of the proposed project related to green sturgeon adults would primarily be related to the alteration of the Sacramento River below the waterline as migrating and holding adults utilize benthic habitat. Increased revetment will likely result in homogenization of the river, affecting the river's sinuosity and holding habitat. In addition, the change in the ecosystem as a result of the removal or reduction of riparian vegetation and IWM likely impacts potential prey items and species interactions that green sturgeon would experience while holding. These changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures. The effects of channelization on upstream migration of green sturgeon are considered minimal as Southern DPS of North American green sturgeon are assumed to be actively migrating in the center of the channel.

(2) ***Larval, Post-larval, and Juvenile Rearing and Migration***

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthicly oriented (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the removal or reduction of riparian vegetation and IWM likely impacts potential prey items and species interactions that green sturgeon would experience while rearing and migrating. These changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures.

In the absence of modeled response data for green sturgeon, NMFS expects responses to long-term, project-related habitat conditions to be similar to juvenile salmonids. Overall, there will be long-term increases over current conditions in the quantity and quality of estuarine and freshwater rearing sites and migration corridors at all project sites. However, some short-term impacts will occur. At RM 49.6 and RM 51.5, initial losses of vegetative cover and IWM are expected to cause injury or death of individuals from reduced growth conditions and increased predation, for the first 10 to 15 years of the project. At RMs 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, and 53.1 long-term deficits in nearshore habitat values under low-flow conditions in the fall are expected to cause injury or death to individuals from reduced growth conditions and increased predation. Growth and survival conditions at fall flow conditions would recover slightly and stabilize because of increases in the extent of shade along the average fall shoreline, but remain negative during years 15 through 50. Because green sturgeon are not as nearshore oriented as juvenile Chinook salmon, the relative proportion of the green sturgeon population that will be affected by these conditions should be low in comparison to salmonids.

c. *Long-term Effects of CDWR Actions on Anadromous Salmonids*

SAM model results for the CDWR sites (Jones and Stokes 2006c) are summarized in Appendix D, Tables 1 through 17. Results for projects proposed as part of the September 2006, amended project description are summarized in Appendix D, Tables 18, 19, and 20. Results are summarized for Chinook salmon and CV steelhead at average seasonal water surface water surface elevations.

The SAM assessment assumed that salmon and steelhead in the action area would not occur at summer flows, and that steelhead also would not occur at fall flows, and, accordingly, did not report any results for that season. Additionally, the SAM assessment considered impacts to Chinook salmon and steelhead at various juvenile life stages and seasons, but did not assess impacts to adults, and did not distinguish between Chinook salmon species because it was assumed that adults occupied the mid-channel habitats and were unlikely to be affected by shoreline construction, and because winter-run Chinook salmon and CV spring-run Chinook salmon would exhibit similar responses to bank protection as a result of similarities in fish size and outmigration timing.

(1) *Adult Migration*

Adult Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon migrate up the Sacramento River from December through July, and CV steelhead may migrate upstream from September through May. These fish use the river channel at the project sites as a migration pathway to upstream spawning habitat. Long-term changes in nearshore habitat are expected to have negligible effects on adults because adult Chinook salmon and steelhead generally use deep, mid-channel habitat during migration.

(2) *Juvenile Rearing and Migration*

The construction of seasonally inundated vegetated benches, vegetated wetland trenches, and the retention and/or placement of riparian vegetation, and IWM at all project sites are designed to benefit juvenile Chinook salmon and steelhead by increasing the availability (*i.e.*, habitat area), accessibility (*i.e.*, frequency of inundation), and quality (*i.e.*, shallow water and in stream cover) of nearshore aquatic habitat and SRA habitat relative to current conditions. Because of these design features, the project is expected to provide an overall long-term increase over current conditions in the quantity and quality of estuarine and freshwater rearing sites and migration corridors for juvenile Chinook salmon and steelhead at all project sites. However, some short- and long-term term impacts will occur. Habitat modifications are expected to reduce the growth and survival of juvenile salmonids at the low-flow, fall water surface elevations for most project sites due to the conversion of natural fine-textured substrate to rock, loss of shallow-water habitat, and reduction of SRA habitat. The placement of IWM will partially offset this conversion, but not completely compensate for habitat modifications to growth and survival conditions. Construction of seasonally inundated shallow water benches, the placement of additional IWM, and the extensive planting of project sites above the MSE will result in substantial increases in short- and long-term (*i.e.*, 5 to 50 years) habitat values at winter and spring flow conditions when the majority of anadromous fish rearing and migrating through the action area. Numerical SAM results for the CDWR sites are shown in Appendix D, Tables 1 through 17. Results are shown for each species, at each average seasonal water surface elevation, over a 50 year period. Tables 1 through 16 show SAM values at each site. Table 17 shows total SAM values for all sites combined. Table 18 and 19 show the SAM values for CDWR sites added as part of the September, 2006, amended project description.

At RMs 69.9, 130.8, 141.4, and 145.9, 154.5, and Bear River RM 10.1, the SAM results show increases in habitat value for all life stages of Chinook salmon and steelhead, under all flow conditions, for the life of the project. Increases for all life stages of steelhead, under all flow conditions also are seen at RMs 85.6 and 164.0, for the life of the project. These increases primarily reflect the positive responses of juveniles to increases in the availability of shallow-water habitat and extent of flooded vegetation on the constructed bench. The addition of IWM also contributes to these increases. All sites would exhibit short-term reductions of instream cover and shade associated with the damage or removal of some riparian vegetation and IWM along the winter-spring shoreline, but these reductions would be completely offset by an immediate increase in the availability of shallow-water habitat following construction. Juvenile fish that are exposed to these sites are expected to experience improved growth and survival conditions compared to existing conditions.

At RMs 85.6, and 164 the project would result in deficits for Chinook salmon juveniles and smolts only at average fall water surface elevations. At RM 85.6, these deficits will occur in year 1 for juveniles and through year 5 for smolts. At RM 164, the deficits will affect juveniles and smolts for the life of the project. At RM 69.9 juvenile Chinook salmon values show only minor deficits for the first five years, before increasing substantially through year 50. Area-weighted response indices would decrease from loss of shallow-water habitat, and increases in bank slope, and substrate size along the average fall shoreline. Individual fish migrating during the fall flow conditions (*i.e.*, November) would be injured or killed by reduced growth conditions and increased predation. Because the abundance of outmigrating fish during these flow conditions is low, relatively few fish are expected to be affected.

At RM 26.5, 32.5, 56.8, Bear River RM 2.4, and Steamboat Slough RM 16.0, short and long-term deficits affect Chinook salmon and steelhead juveniles and smolts, but not always for the entire life of the project. At RM 26.5 and 32.5 deficits affect juveniles and smolts Chinook salmon at the fall-run water surface, for the life of the project, and at the winter and spring water surface elevation for 5 to 25 years. Steelhead juvenile and smolt deficits at RMs 26.5 and 32.5 will occur for 5 to 15 years. At Bear River RM 2.4, small deficits will affect juvenile and smolt Chinook salmon at the fall water-surface elevation for the life of the project, and will affect smolting steelhead through year 5. At Steamboat Slough RM 16.0, deficits will affect juvenile Chinook salmon through year 5 and smolting Chinook salmon through year 25 at the winter and spring water surface elevations. Smolting steelhead at Steamboat Slough RM 16.0 will be affected during winter and spring water surface elevations through year 15. Area-weighted response indices would decrease from loss of shallow-water habitat, and increases in bank slope, loss of riparian vegetation below where the bench features will occur, and substrate size along the average water surface shorelines. Individual fish migrating during periods of deficit would be injured or killed by reduced growth conditions and increased predation.

At 20.8, 56.8, Cache Slough RM 16.5, and Cache Slough 21.8, the project would result in deficits that last for the life of the project. At 56.8, deficits generally would occur for Chinook salmon and steelhead juveniles and smolts for the life of the project, except for smolting Chinook salmon under fall flow conditions. SAM values for smolting Chinook salmon under fall flow conditions are negative through year 5, then become positive through year 50. At RMs 20.8, Cache Slough RM 16.5, and Cache Slough RM 21.8, the project would result in long-term deficits in nearshore habitat values for juvenile and smolt Chinook salmon and steelhead under all flow conditions, for the life of the project. Area-weighted response indices would decrease from loss of shallow-water habitat, and increases in bank slope, and substrate size along the average fall and winter-spring shorelines. Individual fish migrating past these sites during periods of deficit would be injured or killed by reduced growth conditions and increased predation.

At Sacramento RMs 43.3 and 56.1, the project would result in deficits for Chinook salmon and steelhead juveniles and smolts primarily at average winter and spring water surface elevations. For Chinook salmon. these deficits will occur through year 15 for juveniles and through year 5 for smolts. For steelhead, the deficits will affect juveniles through year 25, and smolts through year 15. Bank line-weighted response indices would decrease from loss of shallow-water habitat, and increases in bank slope, and substrate size along the average fall shoreline. Individual fish migrating while habitat conditions are in a deficit may be injured or killed by reduced growth conditions and increased predation.

At Butte Creek RM 14, the project would result in deficits for CV spring-run Chinook salmon and CV steelhead that last for the life of the project. Deficits are expected from converting the fine-textured eroding bank to large, angular rock, and from loss of riparian vegetation. Individual fish migrating past these sites during periods of deficit would be injured or killed by conditions leading to reduced growth and increased predation. Additionally, the project will fill in a large holding and staging pool. However, the pool is located several miles downstream from the nearest adult spring-run Chinook salmon summer holding habitat, so the loss of pool area is not expected to result in a loss of summer holding habitat. Instead, filling the pool is more likely to adversely affect fall-run Chinook salmon, which are known to hold and spawn in the area during fall months.

Overall, the project results in SAM deficits for juvenile and smolt Chinook salmon at fall water surface elevations, and increases for juvenile and smolt Chinook salmon and steelhead at winter and spring water surface elevations, (Appendix D, Table 17). Total, combined values for fall, winter, and spring water surface elevations are negative for juvenile and smolt Chinook salmon during the first year, but increase substantially above existing baseline conditions by year 5, with habitat values increasing for the life of the project. In summary, this means that for all projects combined, habitat impacts will result in reduced growth and survival conditions for juvenile and smolt Chinook salmon at fall water surface elevations for the life of the project, and substantial increases above baseline conditions at winter and spring water surface elevations. Fall deficits are expected to affect relatively few fish, since the majority of rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead rearing and emigration occurs during periods of higher flow that are more accurately represented by overall positive SAM values at average winter and spring water surface elevations. One exception to this is at Butte Creek RM 14. At this site, deficits occur for all life stages and at all flows. Because Butte Creek supports the largest existing population of CV spring-run Chinook salmon in the ESU, it is not necessarily appropriate to group the SAM results from this site with the overall results throughout the project area. Because of this, additional offsite compensation, within the Butte Creek watershed, will be made for the impacts accrued at the bank protection site. This offsite compensation will focus on improving or restoring habitat conditions that create positive SAM values equal to those lost at the site.

d. *Long-term Effects of CDWR Actions on the Southern DPS of North American Green Sturgeon*

(1) *Adult Migration and Holding*

Adult green sturgeon move upstream through the project sites between March and November. Long-term changes in nearshore habitat are expected to have negligible effects on adults because adult sturgeon use deep, mid-channel habitat during migration. The long-term effects of the proposed project related to the Southern DPS of North American green sturgeon adults would primarily be related to the alteration of the Sacramento River below the waterline as migrating and holding adults utilize benthic habitat. Increased revetment will likely result in homogenization of the river and affect the rivers sinuosity, affecting holding habitat. In addition, the change in the ecosystem as a result of the removal or reduction of riparian vegetation and IWM likely impacts potential prey items and species interactions that green sturgeon would experience while holding. These changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures. The effects of channelization on upstream migration of green sturgeon are considered minimal as Southern DPS of North American green sturgeon are assumed to be actively migrating in the center of the channel.

(2) *Larval, Post-larval, and Juvenile Rearing and Migration*

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are bottom-oriented (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the removal or reduction of riparian vegetation and IWM likely impacts potential prey items and species interactions that green sturgeon would experience while rearing and migrating. These changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures.

In the absence of modeled response data for green sturgeon, NMFS expects responses to long-term, project-related habitat conditions to be similar to juvenile salmonids. Overall, there will be long-term increases over current conditions in the quantity and quality of estuarine and freshwater rearing sites and migration corridors at all project sites. However, some short- and long-term impacts are expected. These impacts are expected to occur during years, and flow conditions that correspond with SAM deficits to Chinook salmon and steelhead, as described above under the long-term effects of CDWR actions on anadromous salmonid juvenile rearing and migration. Adverse effects from SAM deficits at some sites are expected to cause injury or death to individuals from reduced growth conditions and increased predation. After year one, SAM values increase above the existing baseline and provide improved rearing and growth conditions. Because green sturgeon are not as nearshore oriented as juvenile Chinook salmon, the relative proportion of the green sturgeon population that will be affected by these conditions should be low in comparison to salmonids.

4. Impacts of Project Monitoring

The Corps' monitoring plan includes direct sampling of juvenile anadromous salmonids to evaluate the effectiveness of integrated project conservation features for protecting Federally listed fish. Other components of the monitoring plan involve photo documentation, and point estimates of substrate size, IWM, riparian vegetation, and other physical project elements. Non-fishery sampling will be passive and is not expected to have any effect of Federally listed fish or designated critical habitat. Although the details of the monitoring effort are not finalized at the time of this biological opinion, fishery monitoring is expected to begin in 2006, and continue for 5 consecutive years, through 2012.

Fishery monitoring involves monthly sampling at selected project locations in the action area throughout the juvenile migration period using boat electrofishing methods. If turbidity is low, passive techniques, including direct underwater observation may be used. NMFS does not expect passive techniques to adversely affect listed fish species or critical habitat. Up to 29 sites may be monitored during periods of no bench inundation, partial bench inundation, and full bench inundation. Sampling will occur once per month throughout the migration and rearing period of juvenile fish in the action area (*i.e.*, November through May). At a maximum each project site is expected to be sampled 6 times per year. However, sampling is expected to rotate through a panel of representative sites, which will reduce the sampling frequency. Electrofishing can result in a variety of effects from simple harassment to injury to the fish (adults and juveniles) and death. There are 2 major forms of injuries from electrofishing; hemorrhages in soft tissues and fractures in hard tissues. Electrofishing can also result in trauma to fish from stress (NMFS 2003a). Recovery from this stress can take up to several days, and during this time the fish are more vulnerable to predation, and less able to compete for resources. Stress-related deaths also can occur within minutes or hours of release, with respiratory failure usually the cause. Electrofishing can have severe effects on adult salmonids, particularly spinal injuries from forced muscle contraction. Studies also found dramatic negative effects of electrofishing on the survival of eggs from electroshocked female salmon (NMFS 2003a). The effects of electrofishing are further described in the Central Valley Research Opinion (NMFS 2003a).

Because of the spatial and temporal aspect of the electrofishing effort, both juvenile and adult salmonids can be exposed to the sampling; however, because this effort is completed along the shoreline, the probability of encountering adults is low. In addition, the study sites for electrofishing are not in the vicinity of adult salmonids in spawning condition or near redds. Juveniles are more likely to be exposed to the sampling activities, but the relatively few studies that have been conducted on juvenile salmonids indicate that spinal-injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish and may therefore be subject to lower injury rates (*e.g.*, Hollender and Carline 1994, Dalbey *et al.* 1996, Thompson *et al.* 1997). McMichael *et al.* (1998) found a 5.1 percent injury rate for juvenile steelhead captured by electrofishing in the Yakima River sub-basin.

One adult Central Valley steelhead and no listed adult Chinook salmon or green sturgeon were captured as a result of IEP electrofishing sampling efforts in 1999, 2001, 2002, and 2003. A total of 8 juvenile Sacramento River winter-run Chinook salmon were captured, one of which died. During the same sampling period, a total of 35 juvenile Central Valley spring-run Chinook salmon were captured (10 in 2002, and 25 in 2003), and 10 juvenile Central Valley steelhead were captured with no mortality. No juvenile green sturgeon were captured. McLain and Castillo (2006) captured Chinook salmon fry in the Delta and the lower Sacramento River at rates that generally ranged from less than one, to almost five fish per minute. Most of the captured fish were classified as Central Valley fall-run Chinook salmon (CV fall-run Chinook salmon (*O. tshawytscha*)). McLain (pers. comm. 2006) estimates that captures in the mainstem Sacramento River north of Sacramento could be as high as 10 fish per minute, and a majority of the fish likely would be fall-run Chinook salmon. McLain (pers. comm. 2006), also estimates that each pass through a bank protection project of 1,000 feet would last about 20 minutes.

Assuming that fish occur at all 29 sites, up to six times per year, and last up to 20 minutes per site, a total of 34,800 fish would be captured. Assuming that 95 percent of the captured fish are non-listed CV fall-run Chinook salmon, based on juvenile abundance estimates at Red Bluff Diversion Dam (Gaines and Martin 2002) only 1,740 fish would be listed salmonids. Assuming a injury rate of 10 percent (a conservative estimate that doubles the level observed by McMichael *et al.* (1998)), 174 listed salmonids may be injured. At a mortality rate of 5 percent (common level reported in the Central Valley), 87 juvenile fish would be killed. If the capture, injury, and mortalities are divided equally between Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead, the monitoring would result in the annual capture of approximately 580 fish, the annual injury of 58 fish, and the annual mortality of 29 fish for each species. The amended project description adds three sites to the monitoring program. However, actual levels should be lower because not all sites will be sampled, and river flows and scheduling complexities are likely to reduce the sampling frequency to fewer than six times per year. No green sturgeon are expected to be captured during electrofishing sampling.

Regardless, the relative number of fish that will be captured, injured, or killed is expected to be relatively low compared to the overall abundance of juvenile Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Because sampling will be limited to nearshore areas, and not in adult migration corridors, no more that 1 adult of each species is expected to be captured each year. The anticipated low levels of capture, injury, and mortality will not result in population level impacts. Monitoring results will be used to validate the effectiveness of project conservation measures for avoiding or minimizing adverse impacts of bank protection projects on Federally listed fish species.

5. Impacts of SRBPP and CDWR Projects on Designated Critical Habitat for Sacramento River Winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead

The action area provides elements of critical habitat that include freshwater rearing and migration and estuarine rearing and migration for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CV steelhead. Specifically, the Sacramento River, Cache Slough, and Steamboat Slough contain critical habitat for all three of these listed salmonids. In the Bear River, the action area is designated critical habitat for CV spring-run Chinook salmon. In the Sacramento River, sites downstream from approximately RM 30, and the Cache Slough and Steamboat Slough sites contain freshwater and estuarine rearing and migration habitat. The sites in the Sacramento River upstream from approximately RM 30, and the Bear River sites contain freshwater rearing and freshwater migration habitat.

Impacts to Sacramento River winter-run critical habitat will occur from the permanent modification of approximately22,182 lf, and 44.4 acres of existing nearshore aquatic and riparian habitat along the Sacramento River. Impacts to CV spring-run Chinook salmon and CV steelhead critical habitat will occur from the permanent modification of approximately 25,801 lf, and 50.9 acres of existing nearshore aquatic and riparian habitat along the Sacramento River, Cache Slough, Steamboat Slough, and the Bear River. Important habitat components within the action area, such as riparian vegetation, channel substrate, IWM, and other elements of SRA cover, shoreline habitat complexity, and refugia, currently are degraded, fragmented and do not contribute beneficially to the conservation value of critical habitat. The proposed habitat modifications are expected to result in adverse impacts to critical habitat that are consistent with past impacts that have resulted in existing site conditions. However, because of the extensive onsite project features such as extensive riparian planting, the creation of seasonally inundated benches, and the installation of IWM, the action is expected to improve the conditions of estuarine and freshwater rearing and migration habitat within the action area. Based on the SAM model results, NMFS expects that although some sites will have long-term habitat impacts, the overall conservation value of critical habitat within the action area will improve over the life of the project. Therefore, we do not expect project-related impacts to result in a reduction of the conservation value of critical habitat.

6. Interrelated or Interdependent Actions

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). There are no interrelated or interdependent actions associated with the proposed action.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Cumulative effects include non-Federal riprap projects. Depending on the scope of the action, some non-Federal riprap projects carried out by State or local agencies do not require Federal permits. These types of actions, and illegal placement of non-Federal riprap are common throughout the action area. The effects of such actions result in continued fragmentation of existing high-quality habitat, and conversion of complex nearshore aquatic to simplified habitats that affect salmonids in ways similar to the long-term effects of the proposed action. Potential cumulative effects may include any continuing or future non-Federal water diversions. Water diversions through intakes serving numerous small, private agricultural lands and duck clubs along the lower Sacramento River contribute to these cumulative effects. These diversions also include municipal and industrial uses as well as water for power plants. Water diversions affect salmonids by entraining, and injuring or killing adult or juvenile fish.

Additional cumulative effects may result from the discharge of point and non-point source chemical contaminant discharges. These contaminants include selenium and numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. The introduction of exotic species may occur when the levees are breached or when separate creeks of river systems are reconnected during various projects. Exotic species can displace native species that provide food for larval fish. Contaminants may injure or kill salmonids by affecting food availability, growth rate, susceptibility to disease, or other physiological processes necessary for survival.

Other potential cumulative effects on fish could include: wave action in the water channel caused by boats that may degrade riparian and wetland habitat and erode banks; dumping of domestic and industrial garbage; urban land uses that result in increased discharges of pesticides, herbicides, oil, and other contaminants into the water; agricultural practices; and unscreened river diversions. These actions and conditions also may injure or kill salmonids by affecting food availability, growth rate, susceptibility to disease, or other physiological processes necessary for survival.

VII. INTEGRATION AND SYNTHESIS

A. Impacts of the Proposed Action on Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, Central Valley Steelhead

NMFS expects that the proposed action will result in adverse short-term, construction-related impacts, O&M-related impacts, habitat impacts, and monitoring impacts that will capture, injure, and kill Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead and their designated critical habitat. Construction-related effects are expected to occur only to juveniles. Juveniles are expected to be affected because of their small size, reliance on nearshore aquatic habitat, and vulnerability to factors that affect their growth and survival. Construction activities will cause turbidity, and inwater disturbance that may injure or kill juveniles during the month of November from temporarily modified behavior that increases susceptibility to predation. Adults should not be injured because their size, preference for deep water, and crepuscular migratory behavior enable them to avoid temporary, nearshore disturbance.

Turbidity related injury and predation will be minimized by implementing the proposed conservation measures such as implementation of BMPs and adherence to Regional Board water quality standards. Fuel spills or use of toxic compounds during project construction could release toxic contaminants into the Sacramento River and could injure or kill salmon and steelhead. Adherence to BMPs that dictate the use, containment, and cleanup of contaminants will sufficiently minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak.

Short-term impacts to juveniles will be related to construction activities that occur within approximately 25,801 lf of aquatic habitat and along the banks of the Sacramento River, the Bear River, Butte Creek, Steamboat Slough, and Cache Slough. These impacts are expected to impact early outmigrants during the month of November, 2006. Relatively few fish are expected to be injured or killed by in-river construction activities because the majority of construction will occur before high flows trigger peak migration, and because the implementation of BMPs and other on-site measures to minimize impacts to the aquatic environment.

O&M impacts will occur for the life of the project and primarily will be caused by infrequent in-water construction and rock placement necessary to maintain the project in functional condition. O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years). Individuals are expected to be injured or killed during the month of November from turbidity-induced predation during the annual placement of the bank protection material of no more than 300 feet per site, and up to 600 cubic yards of material. Relatively few fish are expected to be injured or killed by O&M activities because the majority of construction will occur before high flows trigger peak migration, and because the implementation of BMPs and other on-site measures to minimize impacts to the aquatic environment.

Long-term impacts are associated with the modification of several PCEs of salmon and steelhead critical habitat including freshwater and estuarine areas for rearing and migration. Such modifications result from the replacement of existing aquatic, shoreline, and riparian zones with project features. Temporary or seasonal habitat modifications are expected to result in the following adverse effects: (1) injury or death to rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CV steelhead at RMs 26.9 and 34.5, at all seasonal flow conditions, for the life of the project due to predation in project-created shallow-water wetlands; (2) injury or death to rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CV steelhead at RM 72.2 during fall and winter flows, for the life of the project, due to loss of riparian vegetation during construction; (3) injury or death to rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CV steelhead at RMs 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, 53.1, and 164 during fall flows, for the life of the project, due to conversion of fine grained river substrate to rock; (4) injury or death to rearing Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon at 49.6, 49.9, and 51.5, and smolting Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon at 49.6, 49.9, 50.2, 50.4, and 51.5, during winter and spring flows for the first year of the project, due to a short-term loss of riparian vegetation; (5) injury or death to smolting CV steelhead at RM 49.6 for fifteen years from the construction-related loss of riparian vegetation and IWM; (6) injury or death to juvenile Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon at RM 85.6, at average fall water surface elevations, for 1 year following construction, and to smolting Chinook salmon through year 5; (7) injury or death to rearing and smolting Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon at RM 26.5, and 32.5, 43.3, and 56.1 at the fall water surface elevation for the life of the project, and to rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead at the winter and spring water surface elevations for 5 to 25 years; (8) injury or death at Bear River RM 2.4 to rearing and smolting Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon at fall water surface elevations for the life of the project and to smolting CV steelhead through year five; (9) injury or death at Steamboat Slough RM 16.0 to rearing and smolting Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon for 5 to 25 years after construction at fall, winter, and spring water surface elevations; and (10) injury or death of rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead at RM 20.8, 56.8, Cache Slough RM 16.5, and Cache Slough RM 21.8, at winter, and spring water surface elevations that generally occur for the life of the project, with the exception of 56.8, where smolting Chinook salmon would be injured or killed only for the first five years; (11) injury or death to juvenile and smolting CV spring-run Chinook salmon and CV steelhead at Butte Creek RM 14, for the life of the project.

These adverse impacts should affect relatively few fish for several reasons. First, although the SAM calculates a fish response index at average fall low-flow conditions, the majority of rearing and outmigration occurs during higher flows (*i.e.*, average winter and spring flows) when fish will be exposed to habitat conditions that are substantially better than existing baseline conditions. Secondly, based on the success of riparian revegetation projects at similar projects constructed on the American River, the SAM appears to underestimate the amount of time that it will take for riparian plantings to replace the function of riparian vegetation lost to construction. Although some components of a mature riparian overstory will not recover for decades, many of the most important functional attributes, such as allochthonous food production, and SRA cover, will recover in less than a decade.

In spite of the habitat and species-level impacts that are expected at certain sites, the project will result in substantial long-term habitat improvement during winter and spring flow conditions, when the majority of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead are outmigrating or rearing in the action area. Overall, the proposed actions would result in significant long-term gains in nearshore and SRA habitat values. Appendix B, Figures 1 and 2, and Appendix D, Table 17 demonstrate the typical overall positive fish responses from project actions that will occur over a 50 year period. Long-term benefits to listed salmonids include substantial increases in the amount of shallow water and instream cover available to juvenile Chinook salmon and steelhead during typical winter and spring flows. On-site and off-site conservation measures and integrated design features are expected to minimize spatial and temporal effects by restoring ecological processes that will improve the Environmental Baseline for the species.

Fishery monitoring will capture, injure, and kill juvenile and adult anadromous fish for five years, until 2012. Fish will be captured, injured, and killed from fish sampling for this period between the months of November and May. Although the exact number of fish that will be captured, injured, or killed cannot be determined, the number is expected to be low relative to the overall abundance of the species because sampling at each site NMFS expects that fewer than 10 percent of those captured will be injured, and fewer than 5 percent will be killed. No more than an annual capture of 580 juvenile fish, an annual injury of 58 fish, and an annual mortality of 29 fish is expected for each Federally listed anadromous salmonid ESU or DPS.

B. Impacts of the Proposed Action on the Southern DPS of North American Green Sturgeon

NMFS also expects the action to adversely affect the Federally listed Southern DPS of the North American green sturgeon. Adverse effect to these species is expected to be limited to migrating and rearing larvae, post-larvae, juveniles and holding adults. Juveniles are expected to be affected most significantly because of their small size, reliance on aquatic food supply (allochthonous food production), and vulnerability to factors that affect their feeding success and survival. Construction activities will cause disruptions from increased noise, turbidity, and inwater disturbance that may injure or kill larvae, post-larvae, and juveniles by causing reduced growth and survival as well as increased susceptibility to predation. Adverse affects to adults are primarily limited to the alteration of habitat below the waterline affecting predator prey relationships and feeding success. As is the case for salmonids, the habitat and species-level impacts that are expected at certain sites will result in substantial long-term gains in nearshore and riparian health offering benefits to larvae, post-larvae, juvenile, and adult Southern DPS of North American green sturgeon.

C. Impacts of the Proposed Action on the Survival and Recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead

The adverse effects to Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead within the action area are not expected to affect the overall survival and recovery of the ESUs. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses of habitat through implementation of on-site and off-site conservation measures. Construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or juvenile fish from migrating to downstream rearing areas. The number of individuals actually injured or killed by construction and O&M activities is expected to be small because only fish that are present during the month of November are expected to be affected. Similarly, the number of fish that will be injured or killed as a result of short-and long-term habitat impacts, as indexed by the SAM will be low because the primary loss of habitat condition and function is limited to the low-flow fall water surface elevations, while the majority of juvenile fish are expected to be present during winter and spring months, when seasonal water elevations are higher, and integrated conservation measures such as riparian vegetation, overhanging shade, IWM and engineered benches are inundated and available to the species. Although Federally listed anadromous fish may be present in the action area during this fall months, abundance is relatively low compared to the number of fish that are present during winter months. Therefore, because construction impacts and short-and long-term habitat impacts will avoid the majority of individuals passing through the action area, negative population-level impacts are not anticipated.

Fishery monitoring will capture, injure, and kill juvenile and adult anadromous fish for five years, until 2012. No more than an annual capture of 580 juvenile fish, an annual injury of 58 fish, and an annual mortality of 29 fish is expected for each Federally listed anadromous salmonid ESU or DPS. These rates are not significant compared to the overall abundance of the species, and are not expected to reduce the likelihood of the survival and recovery of Federally listed anadromous salmonids in the action area. Furthermore, monitoring will ensure that project conservation measures are functioning to benefit the species. If monitoring shows that project features are limiting the growth and survival of fish in the action area, then those features will be modified or discontinued. If monitoring shows features that are beneficial, they will continue to be maintained and applied to future projects. Monitoring is an essential component for ensuring that the overall action of stabilizing the levee system does not reduce the likelihood of the species survival and recovery in the action area.

Without the integration of on- and off-site conservation measures, including re-establishing riparian vegetation, IWM, and constructing seasonally inundated shallow-water benches, the adverse effects on the PCEs of Sacramento River winter-run Chinook salmon, Central Valley steelhead and Central Valley spring-run Chinook salmon habitat would significantly reduce the conservation value of their designated critical, and would reduce the ability for these fish to survive and recover in the action area.

Implementation of these conservation measures will ensure that long-term impacts associated with existing, and future bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Successful implementation of all conservation measures is expected to improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead within the action area.

D. Impacts of the Proposed Action on the Survival and Recovery of the Southern DPS of North American Green Sturgeon

The adverse effects to Southern DPS of North American green sturgeon within the action area are not expected to affect the overall survival and recovery of the DPS. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses through implementation of on-site and off-site conservation measures. Construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or larvae, post-larvae, and juvenile fish from rearing or migrating to downstream rearing areas. The number of individuals actually injured or killed is expected to be small compared to the sizes of the respective populations; therefore, population-level impacts are not anticipated.

Implementation of the conservation measures will ensure that long-term impacts associated with existing, and future bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Successful implementation of all conservation measures is expected to improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of the Southern DPS of North American green sturgeon within the action area.

E. Impacts of the Proposed Action on Critical Habitat

Impacts to the designated critical habitat of Sacramento River winter-run Chinook salmon include the long-term modification of approximately 22,182 lf, and 44.4 acres of nearshore aquatic and riparian habitat along the Sacramento River. Impacts to the designated critical habitat of CV spring-run Chinook salmon and CV steelhead include the modification of approximately 25,801 lf, and 50.9 acres of nearshore aquatic and riparian habitat along the Sacramento River, the Bear River, Butte Creek, Steamboat Slough, and Cache Slough. Long-term impacts are associated with the modification of several PCEs of salmon and steelhead critical habitat including freshwater and estuarine areas for rearing and migration. Existing PCEs within the action area, currently are degraded, fragmented and do not contribute beneficially to the conservation value of critical habitat. Although the project will result in some short- and long-term habitat impacts, primarily at fall low-flow conditions, overall, the habitat improvements proposed through on-site conservation measures will result in short- and long-term increases the amount of IWM, SRA cover, shade, and seasonally-inundated shallow-water habitat, all of which contribute to value of freshwater and estuarine habitat sites for juvenile rearing and migration. Therefore, we do not expect project-related impacts to result in a reduction to the conservation value of critical habitat.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of Central Valley spring-run Chinook salmon, and Central Valley steelhead, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the SRFCP Critical Levee Erosion Repair project, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead, and is not likely to destroy or adversely modify the conservation value of their designated critical habitat.

After reviewing the best available scientific and commercial information, the current status of the Southern DPS of North American green sturgeon, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the SRFCP Critical Levee Erosion Repair project, as proposed, is not likely to jeopardize the continued existence of the Southern DPS of the North American green sturgeon.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The Southern DPS of North American green sturgeon was listed as a threatened species, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not become effective until the issuance of a final 4(d) regulation.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps: (1) fails to assume and implement the terms and conditions, or (2) fails to require the contractors to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement (50 CFR §402.14(i)(3)).

A. Amount and Extent of Take

NMFS anticipates incidental take of Sacramento River winter-run Chinook salmon, Central Valley steelhead, Central Valley spring-run Chinook salmon, and the Southern DPS of North American green sturgeon from impacts related to construction, O&M, and through long-term impairment of essential behavior patterns as a result of reductions in the quality or quantity of their habitat. Take is expected to be limited to rearing and smolting juveniles.

NMFS cannot, using the best available information, quantify the anticipated incidental take of individual Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to describe the conditions that will lead to the take.

Accordingly, NMFS is quantifying take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon incidental to SRBPP and CDWR projects in terms associated with the extent and duration of initial construction and O&M activities, and long-term impacts as indexed by the SAM model. The following level of incidental take from project activities is anticipated:

1. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon in the form of injury and death from predation caused by constructed-related turbidity that extends up to 100 feet from the shoreline, and 1,000 feet downstream, along all project reaches for construction that occurs during the month of November, 2006.

2. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, in the form of harm or injury of fish from O&M actions is expected for up to 300 lf of shoreline disturbance from the annual placement of up to 600 cubic yards of material per site for the extent of the project life (*i.e.*, 50 years). Take will be in the form of harm to the species through modification or degradation of juvenile rearing and migration habitat.

3. Take in the form of harm, injury, and death at rearing and smolting Chinook salmon, steelhead, at RM 26.9 and 34.5 at fall water surface elevations within the natural range of tidal cycles, with water depths between 1 and 4 feet, from predation that may occur along 1,509 lf of project-constructed wetland features for 50 years.

4. Take in the form of harm, injury, and death of rearing and smolting Chinook salmon and steelhead, and juvenile green sturgeon at RM 72.2, at fall and winter water surface elevations from the modification of 1,804 lf of nearshore habitat that adversely affects the

quality and quantity of rearing and smolt habitat for 50 years, as measured by negative SAM values listed in Appendix C, Table 3.

5. Take in the form of harm, injury, and death of rearing and smolting Chinook salmon and steelhead, and juvenile green sturgeon at RMs 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, 53.1, and 164, at fall water surface elevations from the modification of 5,470 lf of nearshore habitat that adversely affects the quality and quantity of juvenile Chinook salmon, steelhead, and green sturgeon habitat for 50 years as measured by negative SAM values listed in Appendix B, Tables 1 and 2, and Appendix D, Table 11**.**

6. Take in the form of harm, injury, and death of rearing and smolt Chinook salmon, and juvenile green sturgeon at RMs 49.6, 49.9 and 51.5 for one year at winter and spring water surface elevations; smolting Chinook salmon and green sturgeon at RMs 49.6, 49.9, 50.2, 50.4, and 51.5 for one year during winter and spring water surface elevations; rearing and smolting steelhead, and juvenile sturgeon at RMs 49.6 for fifteen years; and rearing and smolting steelhead at RMs 49.9, and 51.5 for one year following construction from the modification of up to 4,436 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix B, Tables 1 and 2.

7. Take in the form of harm, injury, and death of rearing Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and green sturgeon at 49.6, 49.9, and 51.5, and smolting Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon at 49.6, 49.9, 50.2, 50.4, and 51.5, during winter and spring flows for the first year of the project, due to a short-term loss of riparian vegetation and the modification of up to 3,256 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix B, Tables 1 and 2.

8. Take in the form of harm, injury, and death of smolting CV steelhead at RM 49.6 for fifteen years from the construction-related loss of riparian vegetation and IWM and the modification of up to 298 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix B, Tables 1 and 2.

9. Take in the form of harm, injury, and death of rearing Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and juvenile green sturgeon at RM 85.6, at average fall water surface elevations, for 1 year following construction, and to smolting Chinook salmon through year 5 from the modification of up to 1,055 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D, Table 6.

10. Take in the form of harm, injury, and death of rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and juvenile green sturgeon

at RM 26.5, and 32.5 at the fall water surface elevation for the life of the project, and to rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and juvenile green sturgeon at the winter and spring water surface elevations for 5 to 25 years from the modification of up to 2,900 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D, Tables 2 and 3.

11. Take in the form of harm, injury, and death of smolting Sacramento River winter-run Chinook salmon, and CV spring-run Chinook salmon at Bear River RM 2.4 during fall water surface elevations for the life of the project, and to smolting CV steelhead through year five from the modification of up to 1,339 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D, Table 15.

12. Take in the form of harm, injury, and death of rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and juvenile green sturgeon at Steamboat Slough RM 16.0 for 5 to 25 years after construction at fall, winter, and spring water surface elevations from the modification of up to 130 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D, Table 14.

13. Take in the form of harm, injury, and death of rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and juvenile green sturgeon at RM 20.8, 56.8, Cache Slough RM 16.5, and Cache Slough RM 21.8, at winter, and spring water surface elevations that generally occur for the life of the project, with the exception of 56.8, where smolting Chinook salmon would be injured or killed only for the first five years from the modification of up to 4,020 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D, Tables 1,4,12, and 13.

14. Take in the form of harm, injury, and death of rearing and smolting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and juvenile green sturgeon at RM 43.3, and 56.1 at the fall, winter, and spring water surface elevation for 1 to 25 years, from the modification of up to 1,420 lf of critical habitat that adversely affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D Tables 18 and 19.

15. Take in the form of harm, injury, and death of rearing and smolting CV spring-run Chinook salmon and CV steelhead on Butte Creek at RM 14, at all flow elevations for the life of the project from the modification of up to 1,100 lf of critical habitat that affects the quality and quantity of juvenile Chinook salmon and steelhead habitat as measured by negative SAM values listed in Appendix D Table 20.

16. Take in the form of capture from monitoring activities is not expected to exceed an annual amount 580 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of injury is not expected to exceed an annual amount of 58 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of death from monitoring activities is not expected to exceed an annual amount of 29 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of capture, injury, or death is not expected to exceed one adult fish for each for Federally listed anadromous salmonid ESU of DPS.

The incidental take associated with implementation of additional off-site conservation measures cannot be quantified until site selection and a project description are developed. Once the additional off-site conservation measures are proposed, the Corps shall request an amendment to this biological opinion.

Anticipated incidental take may be exceeded if project activities exceed the criteria described above, if the project is not implemented as described in the three separate BAs prepared for this project, or if the project is not implemented in compliance with the terms and conditions of this incidental take statement.

B. Effect of the Take

NMFS has determined that the above level of take is not likely to jeopardize Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, or the Southern DPS of North American green sturgeon. The effect of this action in the proposed project areas will consist of fish behavior modification, temporary loss of habitat value, and potential death or injury of juvenile Sacramento River winter-run Chinook salmon, Central Valley steelhead, and Central Valley spring-run Chinook salmon, and the Southern DPS of North American green sturgeon.

C. Reasonable and Prudent Measures

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous salmonids.

1. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

2. Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and offsite conservation measures that provide beneficial growth and survival conditions for juvenile salmonids, and the Southern DPS of North American green sturgeon.

D. Terms and Conditions

1. Measure shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

   a. The Corps shall provide a project summary and compliance report to NMFS within 60 days of completion of the proposed action. This report shall describe construction dates, implementation of project conservation measures, and the terms and conditions of the biological opinion; observed or other known effects on the Sacramento River winter-run Chinook salmon, Central Valley steelhead, Central Valley spring-run Chinook salmon, and Southern DPS of North American green sturgeon, if any; and any occurrences of incidental take of the Sacramento River winter-run Chinook salmon, Central Valley steelhead, Central Valley spring-run Chinook salmon, and Southern DPS of North American green sturgeon.

   b. The Corps shall provide a second project summary and compliance report to NMFS within 12 months of the issuance of this biological opinion. This report shall provide a progress update on implementation of the outstanding off-site conservation measures; and details on the off-site location, and project design development for the off-site conservation requirements.

   c. The Corps shall provide additional annual reports, as necessary, to describe the implementation of off-site conservation measures, to summarize O&M actions, and summarize monitoring results.

   d. The Corps shall complete a draft monitoring plan, in cooperation with the IWG agencies, and with NMFS approval, within 120 days of the issuance of the final biological opinion, and a final monitoring plan within 90 days of the completion of construction. The purpose of finalizing the monitoring plan is to develop and refine sampling techniques, protocols, frequency, and duration of monitoring components included in the existing plan.

   e. The Corps shall require CDWR to complete a draft monitoring plan, with the assistance of the IWG agencies, and with NMFS approval, within 120 days of the issuance of the final biological opinion, and a final monitoring plan within 90 days of the completion of construction. The monitoring plan, at a minimum, shall include evaluations of integrated project conservation measures, including seasonally inundated benches, anchored IWM, the planting of riparian vegetation, and other fish habitat protection and enhancement measures, to ensure they are effective, and consistent with SAM assumptions that apply for the life of the project. The monitoring plan also shall include direct fishery monitoring to validate that proposed project conservation measures effectively avoid and minimize adverse effects to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon.

f. The Corps, in coordination with CDWR, and the assistance of the IWG agencies, shall complete a monitoring plan implementation strategy with all critical erosion repair sites. A draft strategy shall be submitted to NMFS for approval within 120 days of the issuance of the final biological opinion, and a final strategy within 90 days of the completion of construction.

g. The Corps shall update the SAM to include the Southern DPS of North American green sturgeon.

h. The Corps shall in cooperation with CDWR, and the IWG agencies, and other appropriate flood control agencies and experts, as deemed necessary, consider conducting a re-evaluation of the SAM to determine, at a minimum, if recent modifications adopted for the evaluation of the critical sites should be adopted into the overall assessment framework. Application of the Standard Assessment Methodology to recent bank protection projects in the Sacramento River and Lower American River has resulted in several technical and procedural modifications that are currently being applied to improve the SAM's accuracy and precision in quantifying species impacts and benefits associated with specific project features. Additional modifications may be warranted to improve the utility of the SAM during the planning, design, and evaluation phases of future projects. Therefore, DWR and other members of the IWG should reexamine the SAM and develop and implement an action plan to further improve the utility of the SAM in addressing the design and assessment needs of future levee protection and floodplain restoration projects.

2. Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and offsite conservation measures that provide beneficial growth and survival conditions for juvenile salmonids.

   a. The Corps shall ensure that to the maximum extent practicable, bench features are constructed at elevations that maximize seasonal inundation rates, and corresponding availability to juvenile anadromous, while maintaining bank protection integrity, and promoting the establishment of riparian vegetation suitable for the site.

   b. The Corps shall ensure that CDWR minimizes the removal of existing riparian vegetation and IWM to the maximum extent practicable to install bank protection features, and that where appropriate, removed IWM will be anchored back into place.

c. The Corps also shall ensure to the maximum extent practicable, and without adversely affecting engineering and flood protection integrity of the project, that measures are taken to include large trees such as oak, sycamore, and cottonwood, into the planting schedule of all sites where appropriate, and outside of 3:1 levee projection.

d. The Corps also shall ensure to the maximum extent practicable, and without adversely affecting engineering and flood protection integrity, or the growth and survival of existing vegetation, that measures are taken to integrate soil into project sites by using means that are determined to be feasible and appropriate.

e. The Corps shall require CDWR to develop an irrigation schedule appropriate for establishing vegetation plantings within the three year O&M period, and consistent with the SAM assumptions for riparian survival.

f. The Corps, in cooperation with the CDWR, shall develop a habitat and species compensation strategy within 6 months of issuance of the final biological opinion. The purpose of developing a strategy is to ensure that the adverse effects of bank protection projects that are not fully compensated for through onsite, integrated conservation measures, are compensated in a timely manner that minimizes temporal impacts to listed fish and their habitat. The strategy will be based on the results of final SAM assessments of all sites, and must be approved by NMFS. Any additional compensation needs generated through this plan shall be implemented within 12 months of the proposed action.

Reports and notifications required by these terms and conditions shall be submitted to:

Sacramento Area Office
National Marine Fisheries Service
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X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. These conservation recommendations include discretionary measures that the Corps can implement to avoid or minimize adverse effects of a proposed action on a listed species or critical habitat or regarding the development of information.

NMFS provides the following conservation recommendations that would avoid or reduce adverse impacts to listed salmonids:

1. The Corps, under the authority of section 7(a)(1) of the Act, should implement recovery and recovery plan-based actions within and outside of traditional flood damage reduction projects.

2. The Corps should prepare a Supplemental EIS/EIR for the SRBPP that acknowledges the listing of five fish species since 1987 as significant and discloses to the public and resource agencies the detrimental, ecosystem-scale effects of riprapping, as described in USFWS (2000).

3. The Corps and CDWR should continue to focus on retaining, restoring and creating river riparian corridors in the recovery of the listed salmonid species within their flood control plan.

4. The Corps and CDWR should make set-back levees integral components of the Corp's authorized bank protection or ecosystem restoration efforts.

5. The Corps should make more effective use of ecosystem restoration programs, such as those found in Sections 1135 and 206 of the respective Water Resource Developments Acts of 1986 and 1996. The section 1135 program seems especially applicable as the depressed baselines of the Sacramento River winter-run Chinook salmon, Central Valley steelhead, and Central Valley spring-run Chinook salmon are, to an appreciable extent, the result of the Corps' SRBPP program.

6. The PL 84-99 authority should not be used to apply rock revetment to sites where only earthen banks existed previously or which suffer from design flaws not related to erosion.

7. The Corps should, when appropriate, apply the recent advances in biotechnical bank protection design that were developed for these emergency repair sites, to projects designed and constructed under the PL 84-99 authority.

8. The Corps and CDWR should incorporate the costs of conducting lengthy planning efforts, involved consultations, implementation of proven off-site conservation measures, and maintenance and monitoring requirements associated with riprapping into each project's cost-benefit analysis such that the economic benefits of set-back levees are more accurately expressed to the public and regulatory agencies. This includes a recognition of the economic value of salmonids as a commercial and sport fishing resource.

9. The Corps and CDWR should conduct or fund studies to identify set-back levee opportunities, at locations where the existing levees are in need of repair or not,

where set-back levees could be built now, under the SRBPP, or other appropriate Corps authority. Removal of the existing riprap from the abandoned levee should be investigated in restored sites and anywhere removal does not compromise flood safety.

10. The Corps and CDWR should begin early intervention bank protection efforts using set-back levees, and biotechnical approaches, which may then preclude later having to use rock fill and/or rock riprap to achieve engineering goals.

11. As recommended in the NMFS Proposed Recovery Plan for the Sacramento River winter-run Chinook Salmon, the Corps should preserve and restore riparian habitat and meander belts along the Delta with the following actions: (1) avoid any loss or additional fragmentation of riparian habitat in acreage, lineal coverage, or habitat value, and provide in-kind mitigation when such losses are unavoidable (*e.g.*, create meander belts along the Sacramento River by levee set-backs), (2) assess riparian habitat along the Sacramento River from Keswick Dam to Chipps island and along Delta waterways within the rearing and migratory corridor of juvenile winter-run Chinook salmon, (3) develop and implement a Sacramento River and Delta Riparian Habitat Restoration and Management Plan (*e.g.*, restore marshlands within the Delta and Suisun Bay), and (4) amend the Sacramento River Flood Control and SRBPP to recognize and ensure the protection of riparian habitat values for fish and wildlife (*e.g.*, develop and implement alternative levee maintenance practices).

12. Section 404 authorities should be used more effectively to prevent the unauthorized application of riprap by private entities.

To be kept informed of actions minimizing or avoiding adverse effects, or benefiting listed or special status species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the SRFCP Critical Levee Erosion Repair project. Reinitiation of formal consultation is required if: (1) the amount or extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action, including the avoidance, minimization, and compensation measures listed in the *Description of the Proposed Action* section is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

Agency:	U.S. Army Corps of Engineers Sacramento District
Activity:	Sacramento River Flood Control Project, Critical Levee Erosion Repair project
Consultation Conducted By:	Southwest Region, National Marine Fisheries Service
File Number:	151422SWR2005SA00115
Date Issued:	

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

This document represents the National Marine Fisheries Service's (NMFS) Essential Fish Habitat (EFH) consultation based on our review of information provided by the U.S. Army Corps of Engineers (Corps) on the proposed Sacramento River Flood Control Project (SRFCP) Critical Levee Erosion Repair project. The Magnuson-Stevens Fishery Conservation Act (MSA) as amended (U.S.C 180 et seq.) requires that EFH be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NMFS on activities which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies. The geographic extent of freshwater EFH for Pacific salmon in the Sacramento River includes waters currently or historically accessible to salmon within the Sacramento River, Cache Slough, Steamboat Slough, and the Bear River.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle.

The biological opinion for the SRFCP Critical Levee Erosion Repair project addresses Chinook salmon listed under the both the Endangered Species Act (ESA) and the MSA that potentially will be affected by the proposed action. These salmon include Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), and Central Valley spring-run Chinook salmon (*O. tshawytscha).* This EFH consultation will concentrate on Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) because they are covered under the MSA but not listed under the ESA.

Historically, Central Valley fall-run Chinook salmon generally spawned in the Central Valley and lower-foothill reaches up to an elevation of approximately 1,000 feet. Much of the historical fall-run spawning habitat was located below existing dam sites and the run therefore was not as severely affected by water projects as other runs in the Central Valley.

Although fall-run Chinook salmon abundance is relatively high, several factors continue to affect habitat conditions in the Sacramento River, including loss of fish to unscreened agricultural diversions, predation by warm-water fish species, lack of rearing habitat, regulated river flows, high water temperatures, and reversed flows in the Delta that draw juveniles into State and Federal water project pumps.

A. Life History and Habitat Requirements

Central Valley fall-run Chinook salmon enter the Sacramento River from July through December, and late fall-run enter between October and March. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep provided that the there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding one foot and velocities ranging from one to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from one to four inches in diameter with less that 5 percent fines (Reiser and Bjornn 1979).

Fall-run Chinook salmon eggs incubate between October and March, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

II. PROPOSED ACTION.

The Corps, Reclamation Board, and the California Department of Water Resources (CDWR) propose to implement levee erosion protection at 29 sites in the Sacramento River, Cache Slough, Steamboat Slough, and the Bear River. The proposed action was amended by the Corps in September, 2006. The amended project description included a site extension at RM 53.1, the addition of three sites at Sacramento RM 43.3, 56.1, and Butte Creek RM 14. The amended proposed action is described in the *Description of the Proposed Action* section of the preceding biological opinion (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the preceding biological opinion (Enclosure 1) for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, and threatened Central Valley steelhead. A summary of the effects of the proposed action on Central Valley fall-/late fall-run Chinook salmon are discussed below.

Adverse effects to Chinook salmon habitat will result from construction related impacts, operations and maintenance impacts, and long-term impacts related to modification of aquatic and riparian habitat at the 29 project sites. Primary construction related impacts include riprapping approximately 25,801 lf riverbank. Integrated conservation measures to minimize adverse effects of riprapping will be applied to all sites. Conservation measures include construction of seasonally inundated terraces that will be planted with riparian vegetation. Instream woody material (IWM) will be placed both below and above the mean summer water surface elevatation (MSW) to provide habitat complexity, refugia, and food production of juvenile anadromous fish.

In-channel construction activities such as vegetation removal, grouting, and rock placement will cause increased levels of turbidity. Turbidity will be minimized by implementing the proposed conservation measures such as implementation of BMPs and adherence to Regional Board water quality standards. Fuel spills or use of toxic compounds during project construction could release toxic contaminants into the Sacramento River. Adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak.

The effects of O&M actions will be similar to construction impacts. The Corps expects to place no more than 600 tons of rock annually. Most actions are expected to occur during the summer when anadromous fish are not expected to be present. Additionally, since O&M actions will not occur every year, and actions will be specific and localized in nature, O&M impacts will be smaller and shorter in duration.

At some sites, there will be short and long-term losses of habitat value, but at a majority of sites, habitat features important to salmon growth and survival will increase over the life to the project. Overall, the action will result in a net increase in habitat conditions for Chinook salmon that essential to their survival and growth, especially at winter and spring flows when the majority of fish are outmigrating through the action area. This net increase is expected to maintain and improve the conservation value of the habitat for Chinook salmon and avoid habitat fragmentation that typically is associated with riprapping.

IV. CONCLUSION

Upon review of the effects of SRFCP Critical Levee Erosion Repair project, NMFS believes that the project will result in adverse effects to the EFH of Pacific salmon protected under the MSA.

V. EFH CONSERVATION RECOMMENDATIONS

Considering that the habitat requirements of fall-run within the action area are similar to the Federally listed species addressed in the preceding biological opinion (Enclosure 1), NMFS recommends that Terms and Condition 1a through 1h, 2a through 2f, as well as all the Conservation Recommendations in the preceding biological opinion prepared for the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead ESUs be adopted as EFF Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR ' 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

VI. LITERATURE CITED

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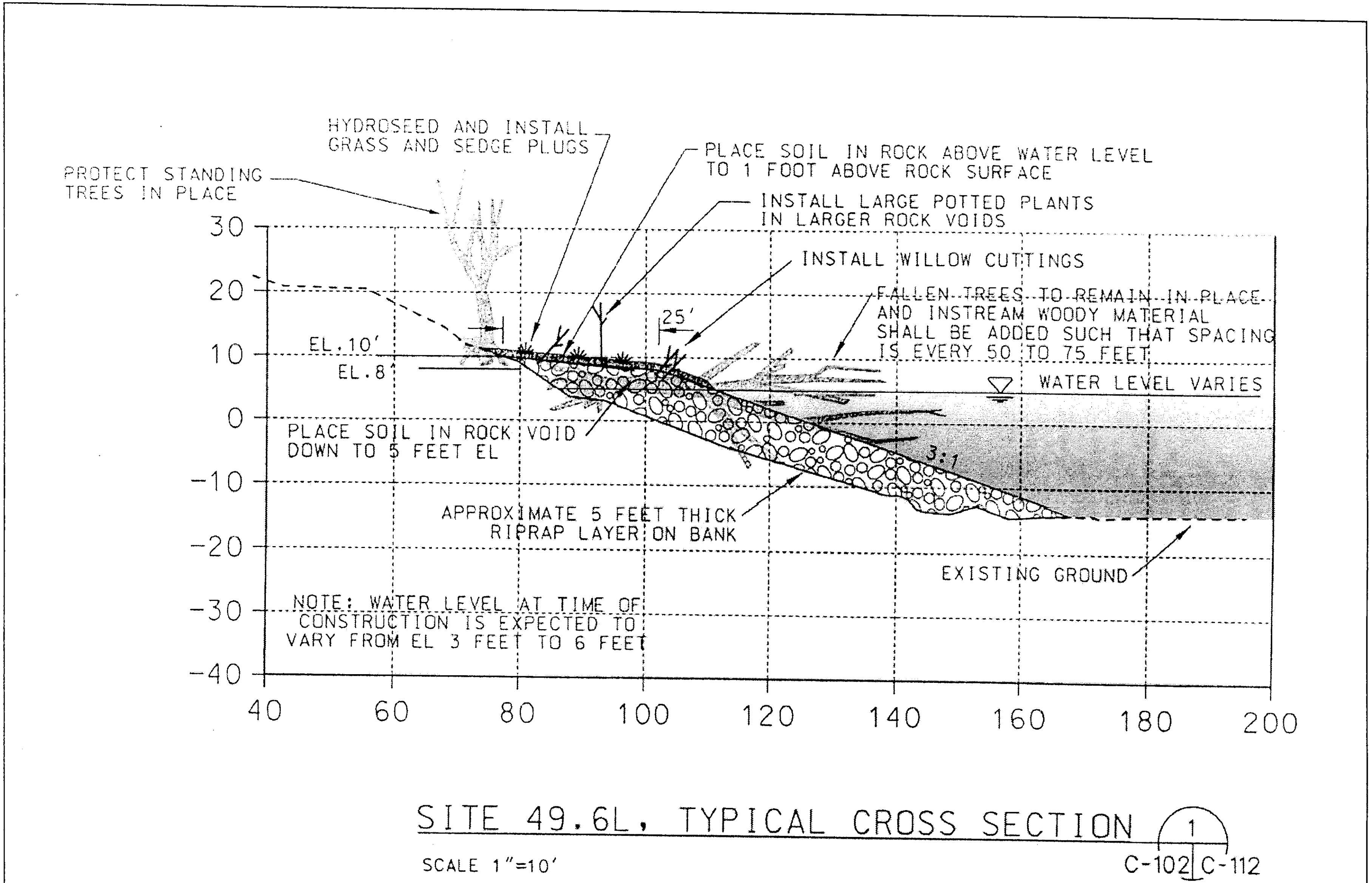
Appendix A

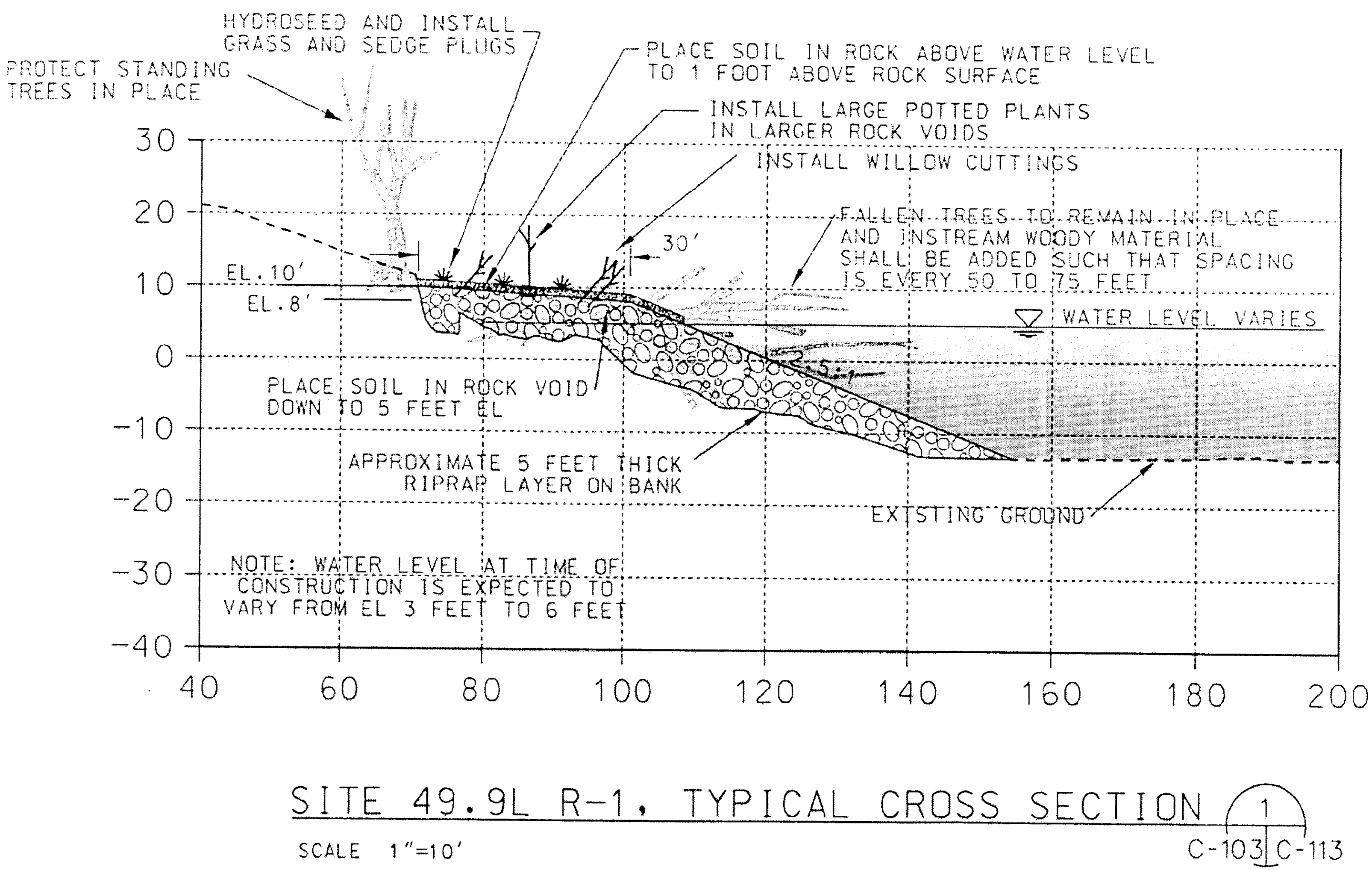
Cross Sectional Profiles
for
SRBPP Actions
at
RMs 26,9, 34,5, 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, 53.1, 72.2, 99.3, and 123.5
and
CDWR Actions
at
Cache Slough, RMs 16.5 and 21.8
Steamboat Slough, RM 20.8
Sacramento River, RMs 20.8, 26.5, 32.5, 56.8, 69.9, 85.6, 130.8, 141.4, 145.9, 154.5, 164
and
Bear River, RMs 2.4 and 10.1



Source: USACE

Jones & Stokes

Figure 1
Typical Cross-Section at Site 49.6 (90% Design)
Pocket Bank Protection Project

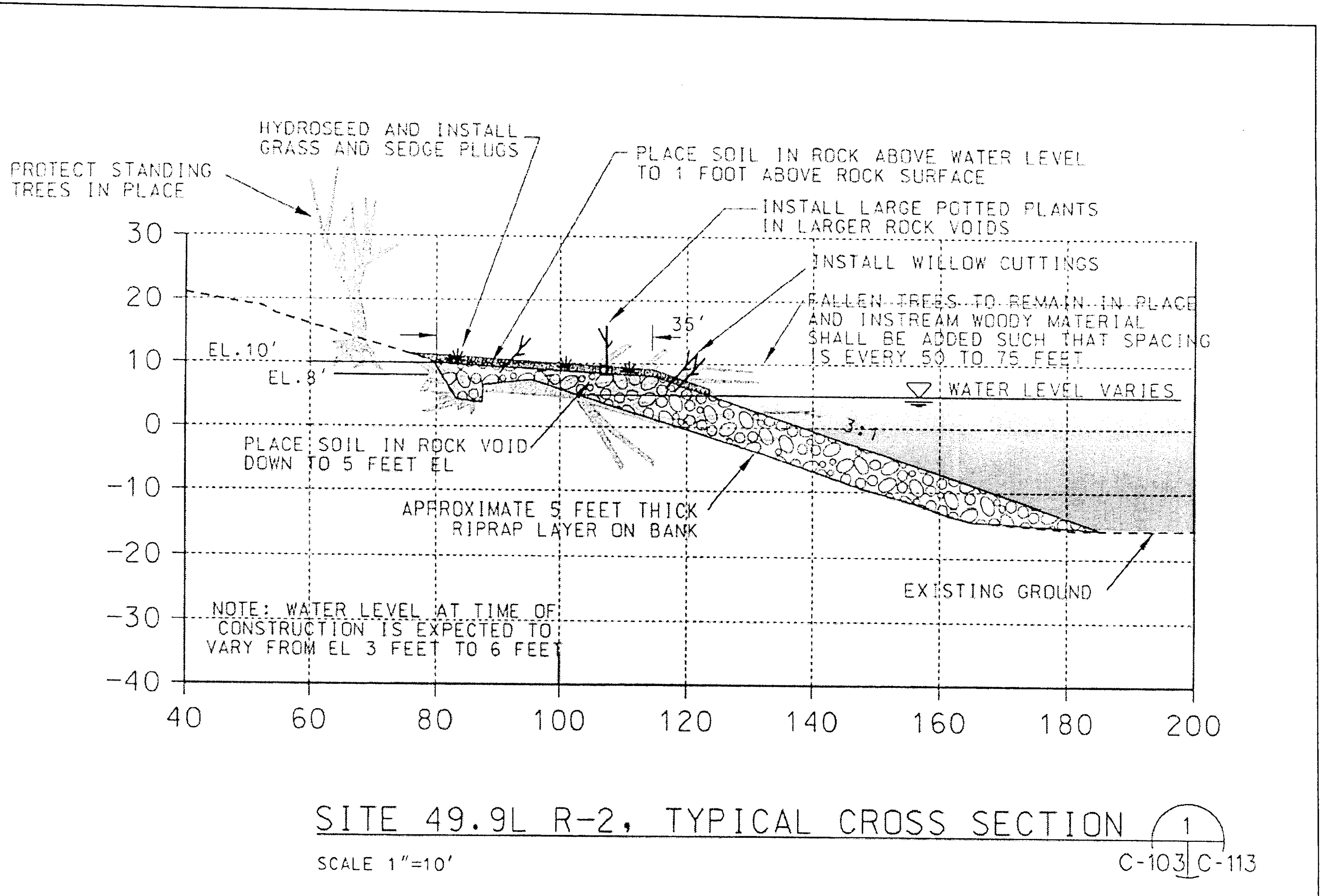


Source: USACE

03613.03 020

Jones & Stokes

Figure 2
Typical Cross-Section at Site 49.9, Reach 1 (90% Design)
Pocket Bank Protection Project



Source: USACE

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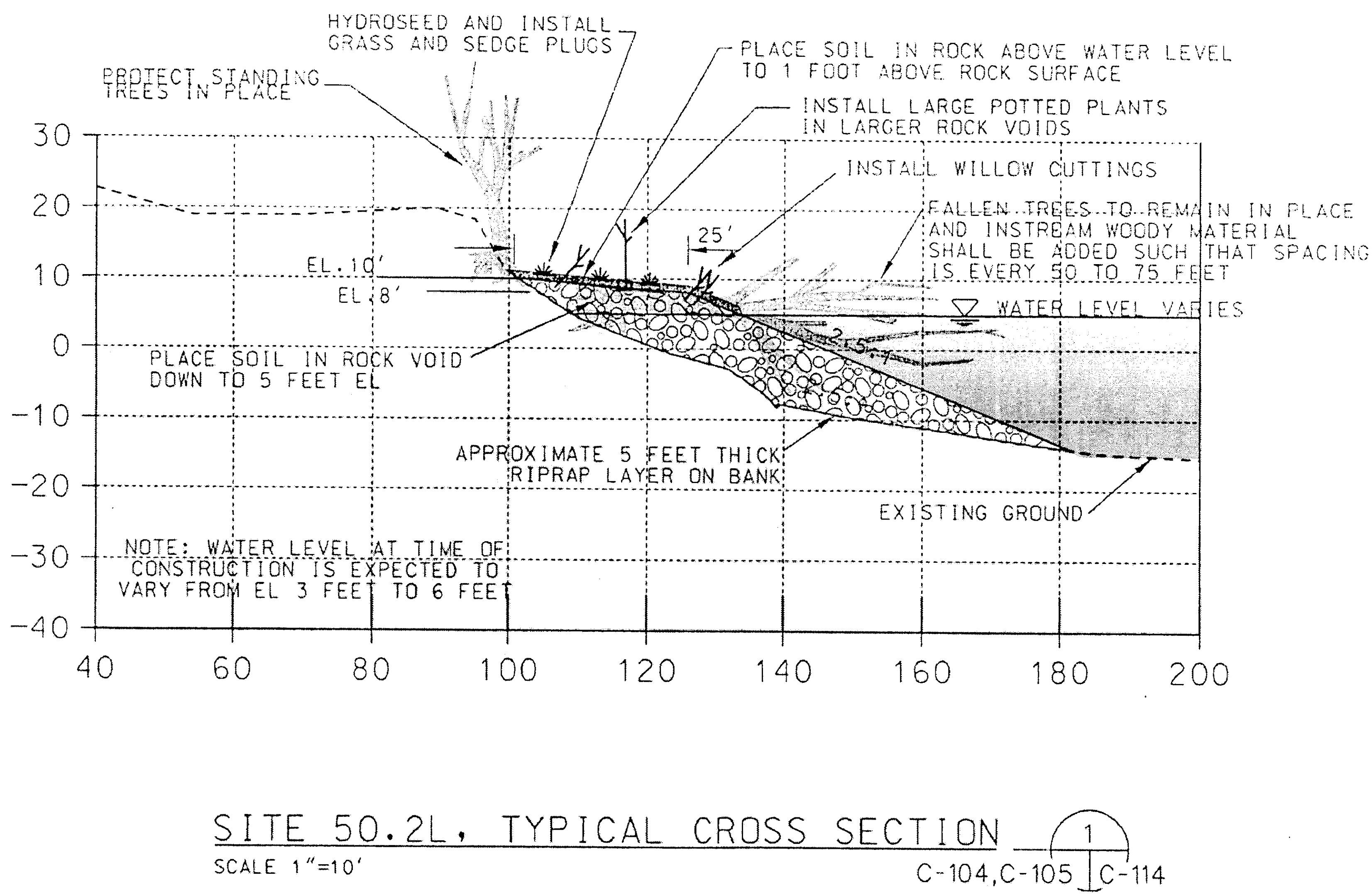
Jones & Stokes

Figure 3
Typical Cross-Section at Site 49.9, Reach 2 (90% Design)
Pocket Bank Protection Project



Source: USACE

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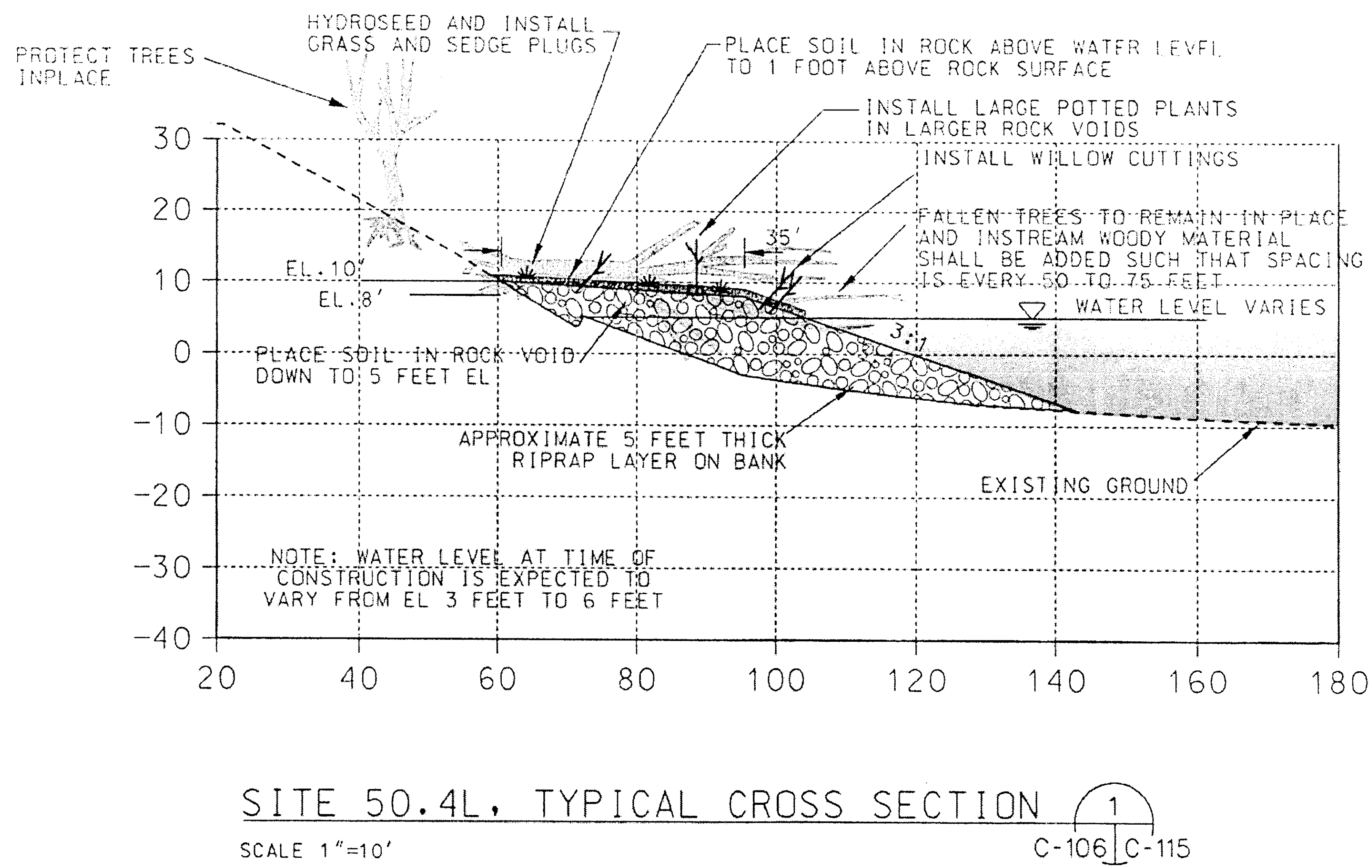
Jones & Stokes

Figure 4

Typical Cross-Section at Site 50.2 (90% Design)

Pocket Bank Protection Project



Source: USACE

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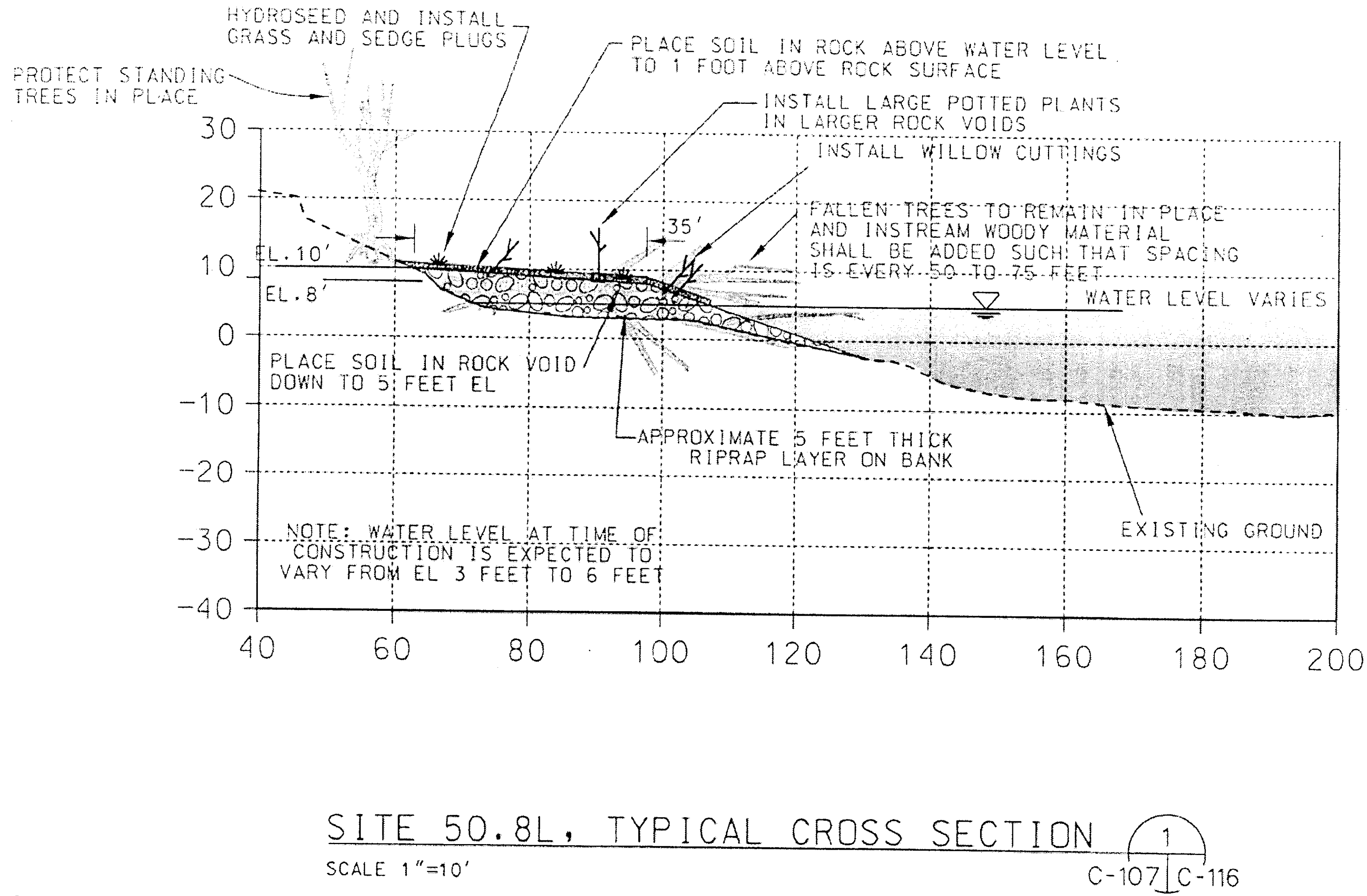
Jones & Stokes

Figure 5
Typical Cross-Section at Site 50.4 (90% Design)
Pocket Bank Protection Project



Source: USACE

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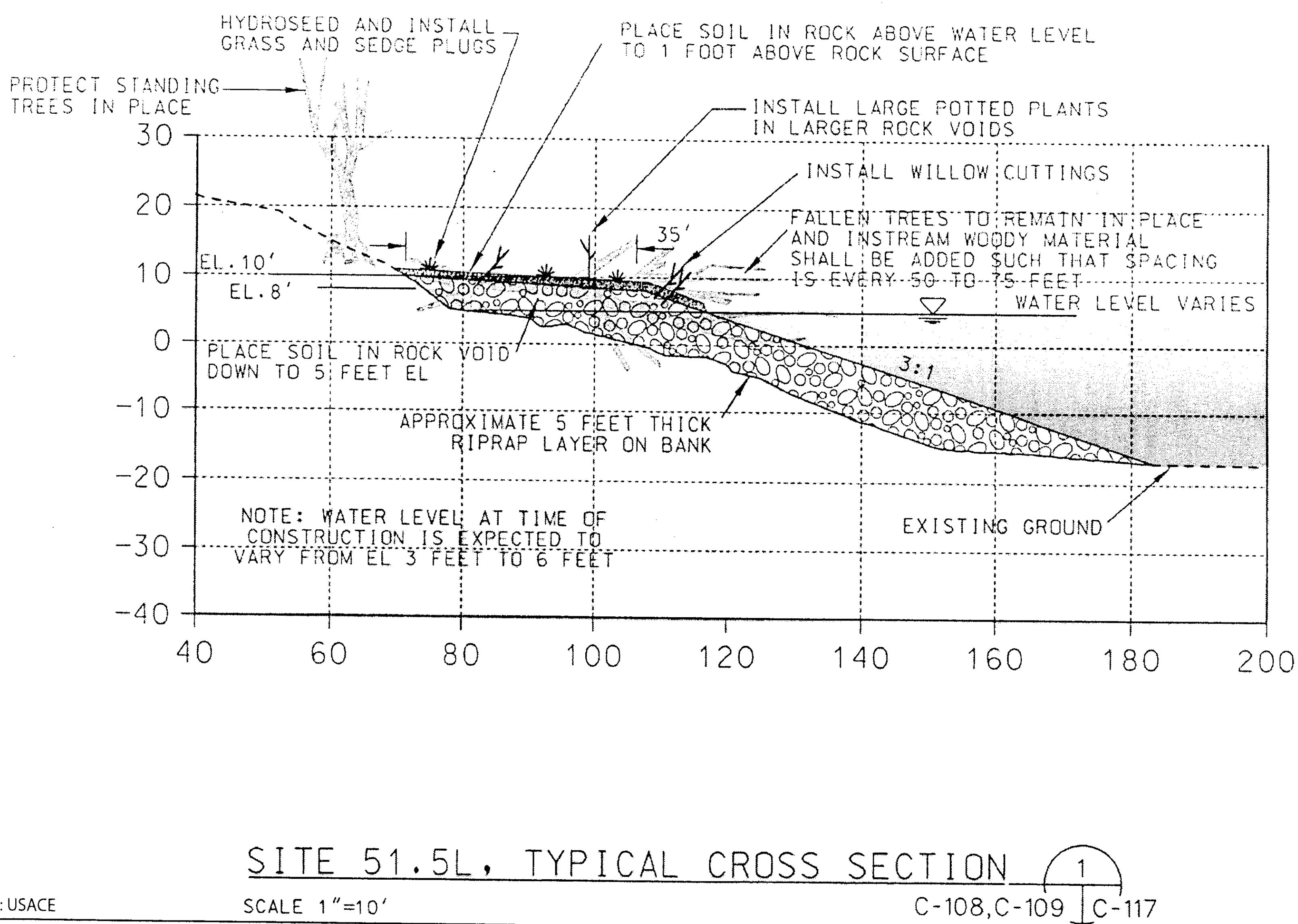
Jones & Stokes

Figure 6

Typical Cross-Section at Site 50.8 (90% Design)

Pocket Bank Protection Project



Source: USACE

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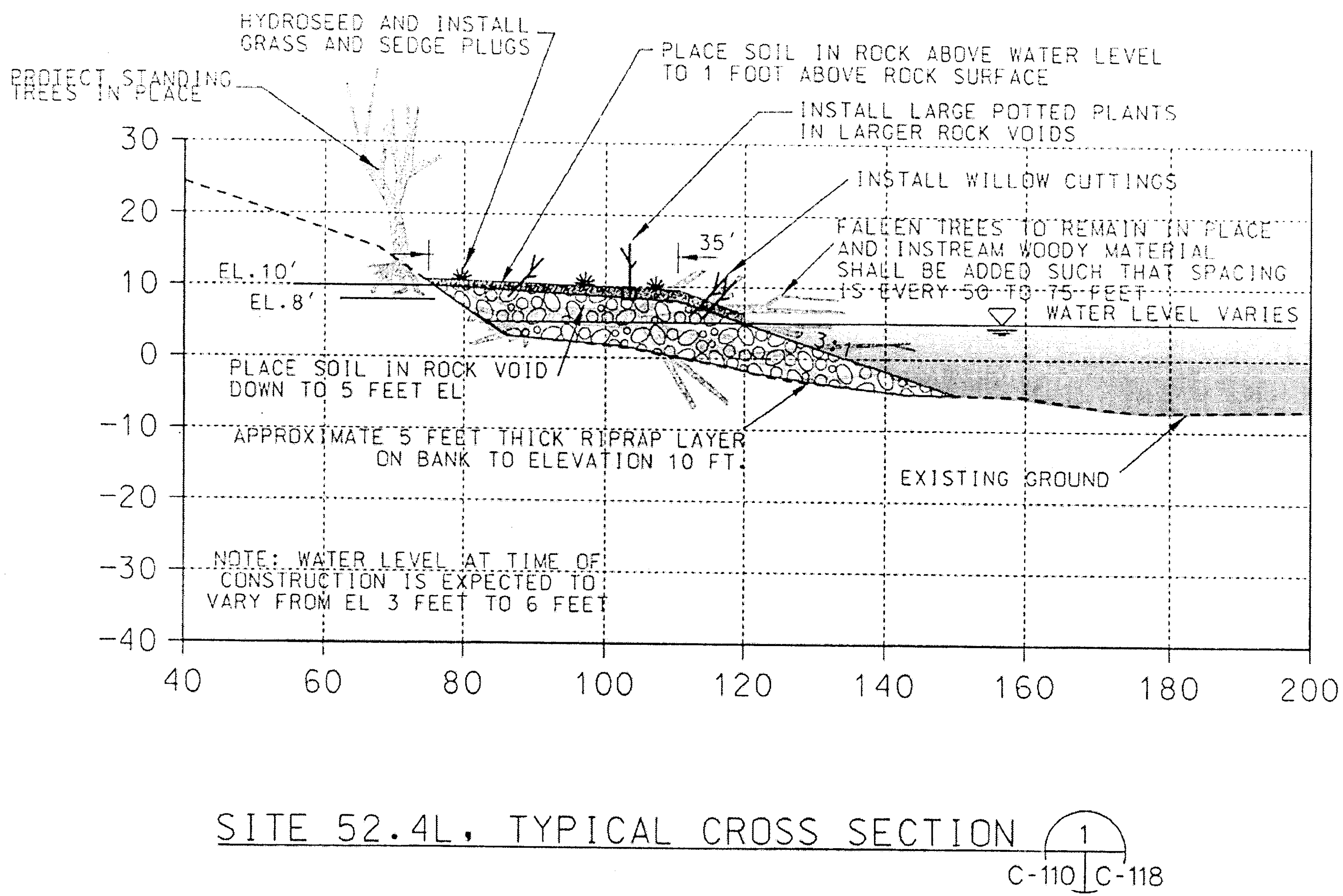
Jones & Stokes

Figure 7

Typical Cross-Section at Site 51.5 (90% Design)

Pocket Bank Protection Project



Source: USACE

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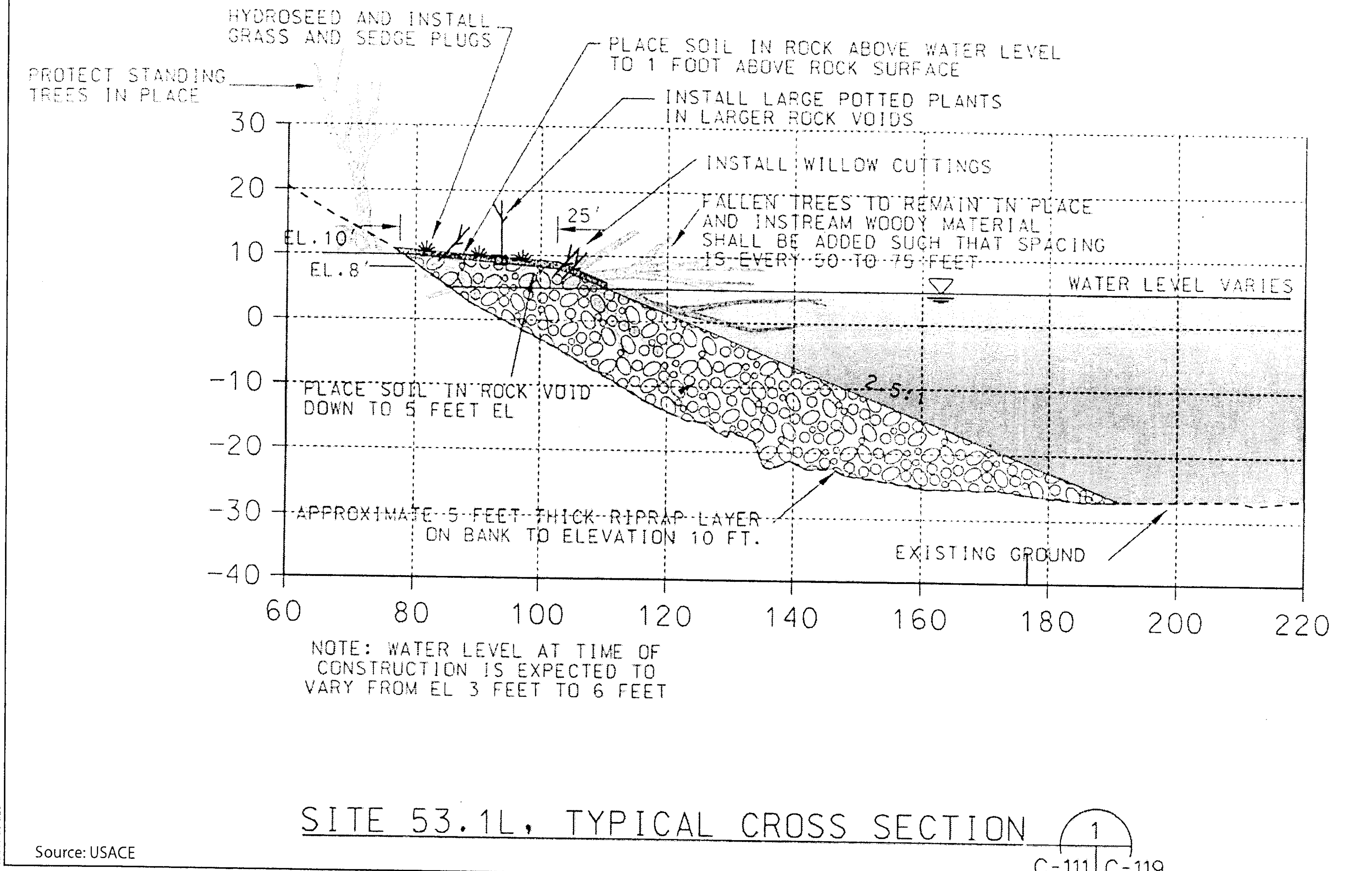
Jones & Stokes

Figure 8
Typical Cross-Section at Site 52.4 (90% Design)
Pocket Bank Protection Project



Source: USACE

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Jones & Stokes

Figure 9

Typical Cross-Section at Site 53.1 (90% Design)

Pocket Bank Protection Project

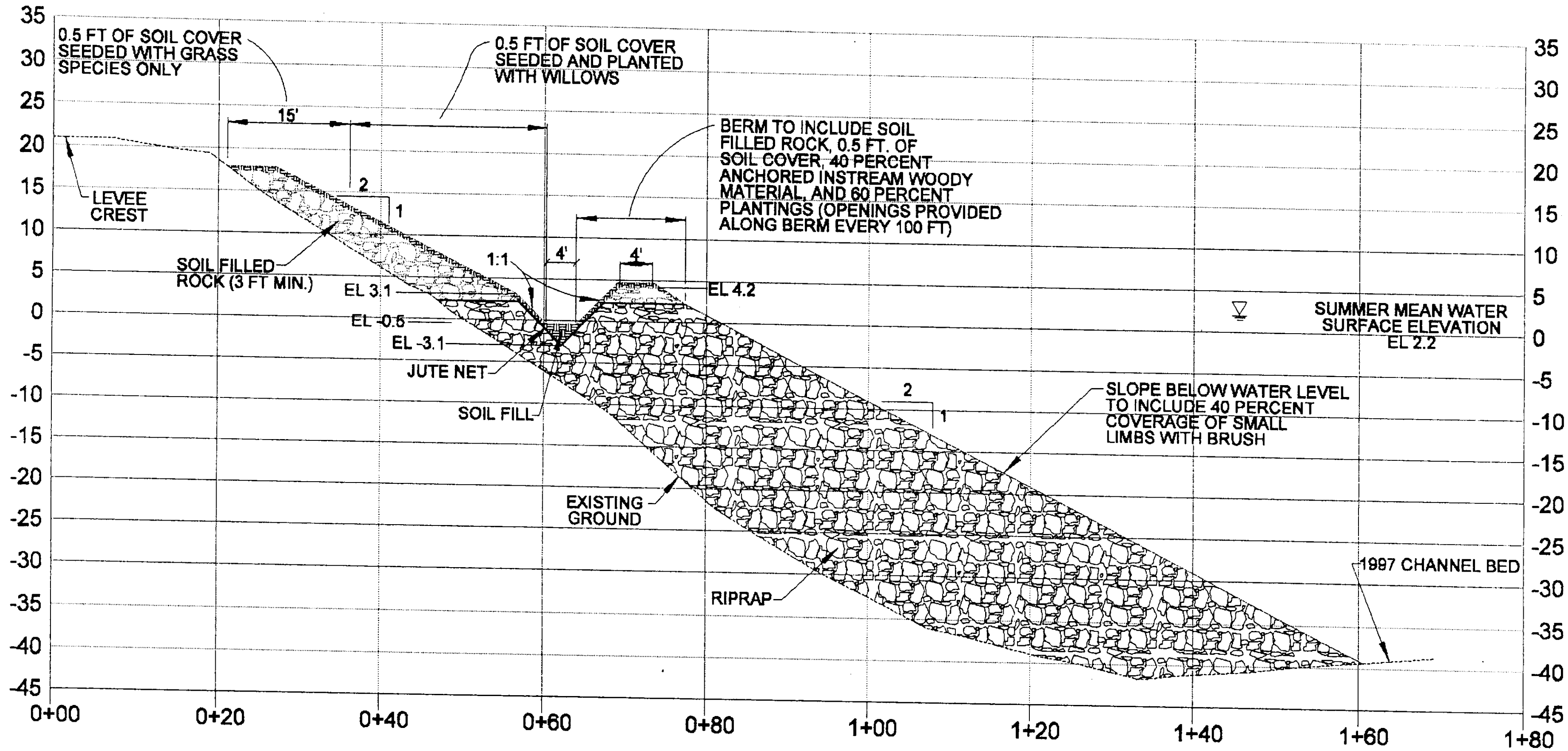
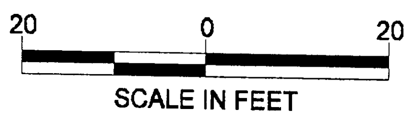


Figure 10
Typical Cross Section
RM 26.9



MAY 4, 2006

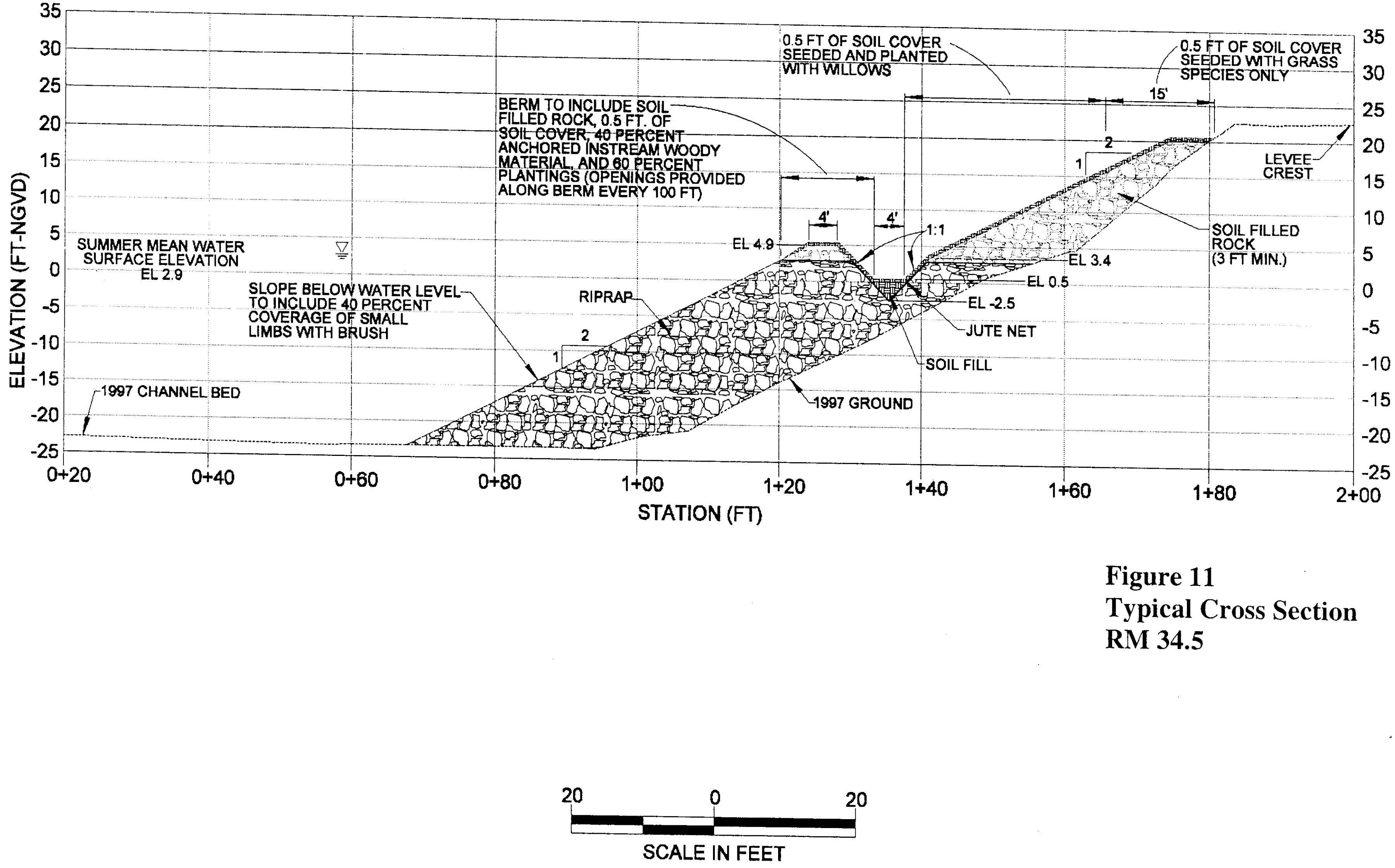


Figure 11
Typical Cross Section
RM 34.5

MAY 4, 2006

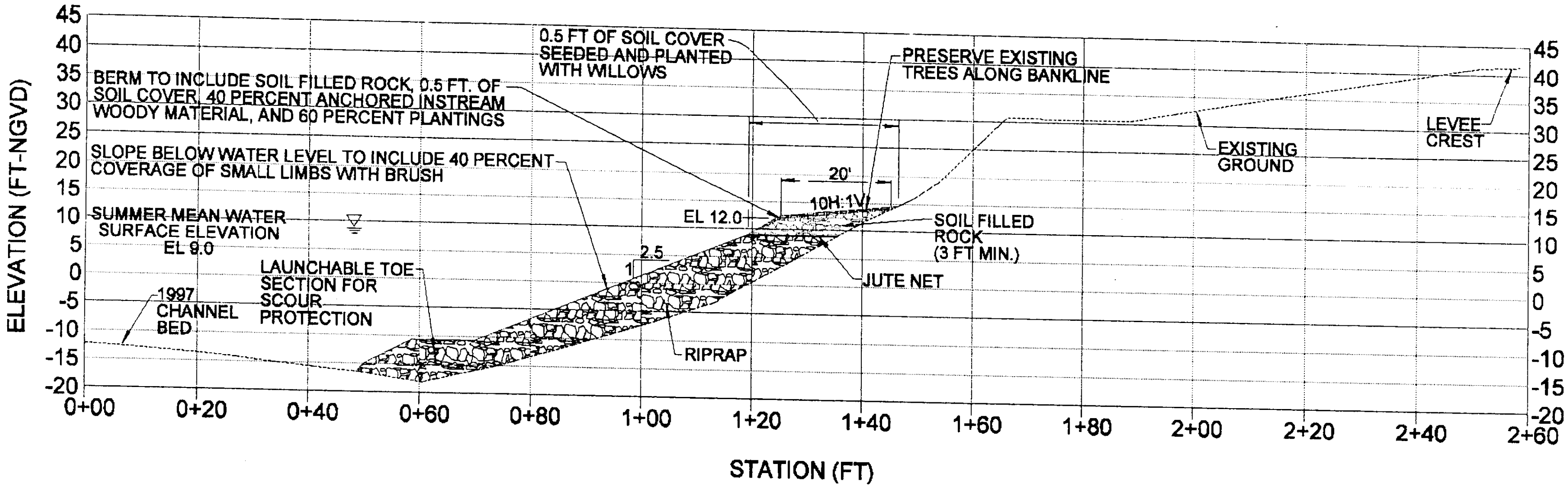
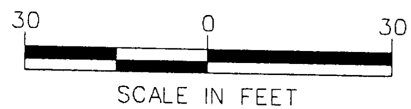


Figure 12
Typical Cross Section
RM 72.2



MAY 4, 2006

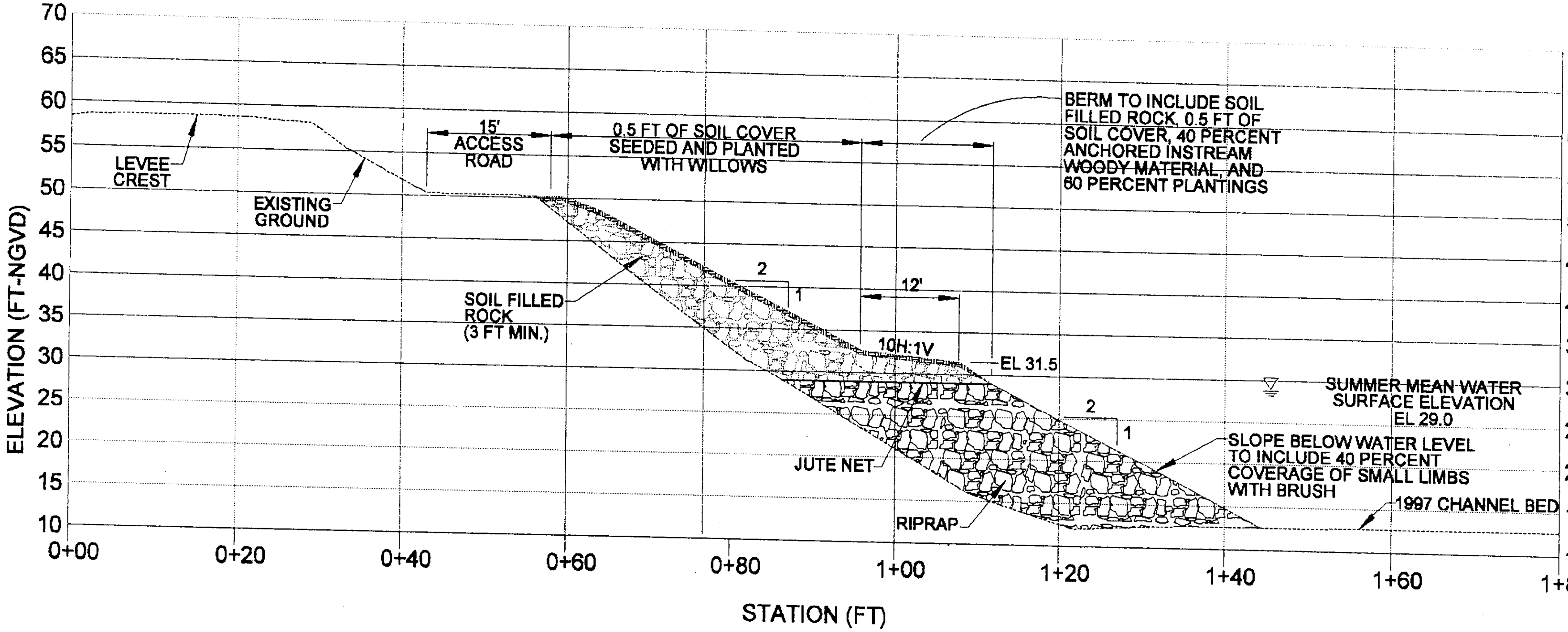
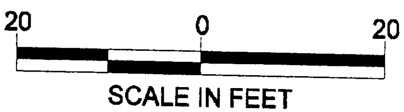


Figure 14
Typical Cross Section
RM 123.5



MAY 4, 2006

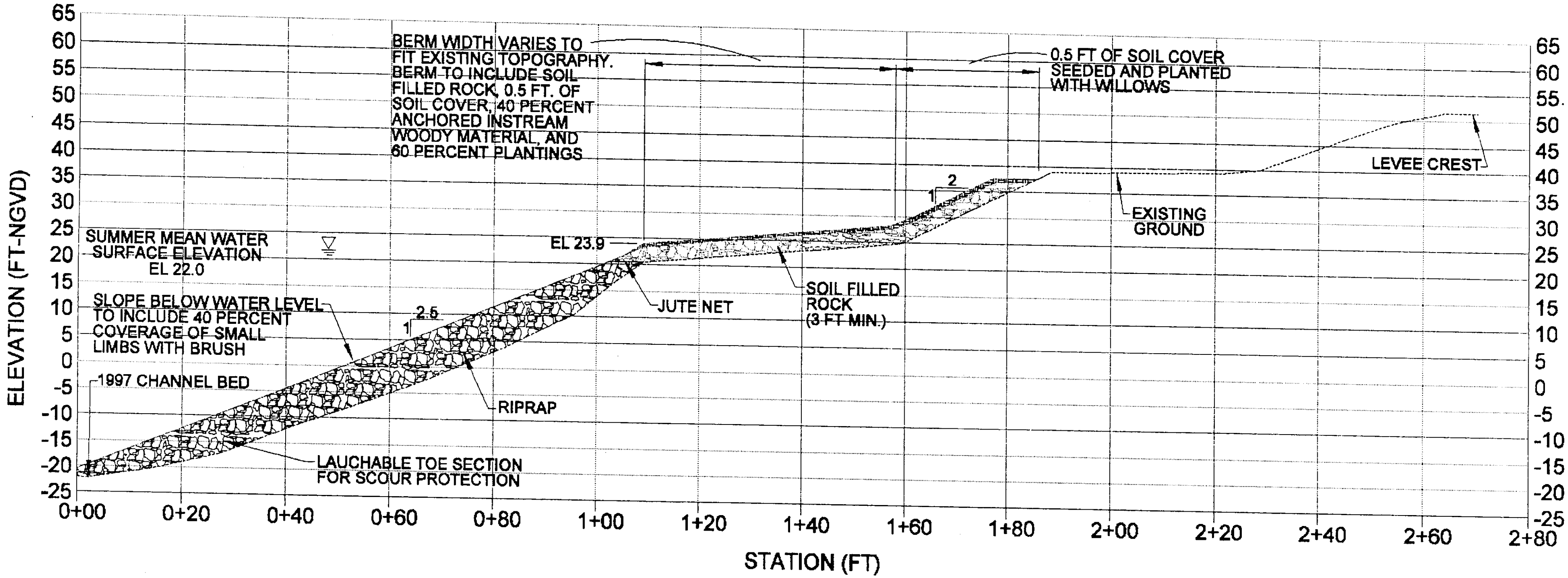
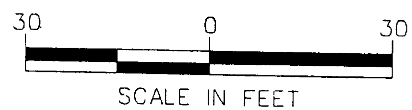


Figure 13
Typical Cross Section
RM 99.3

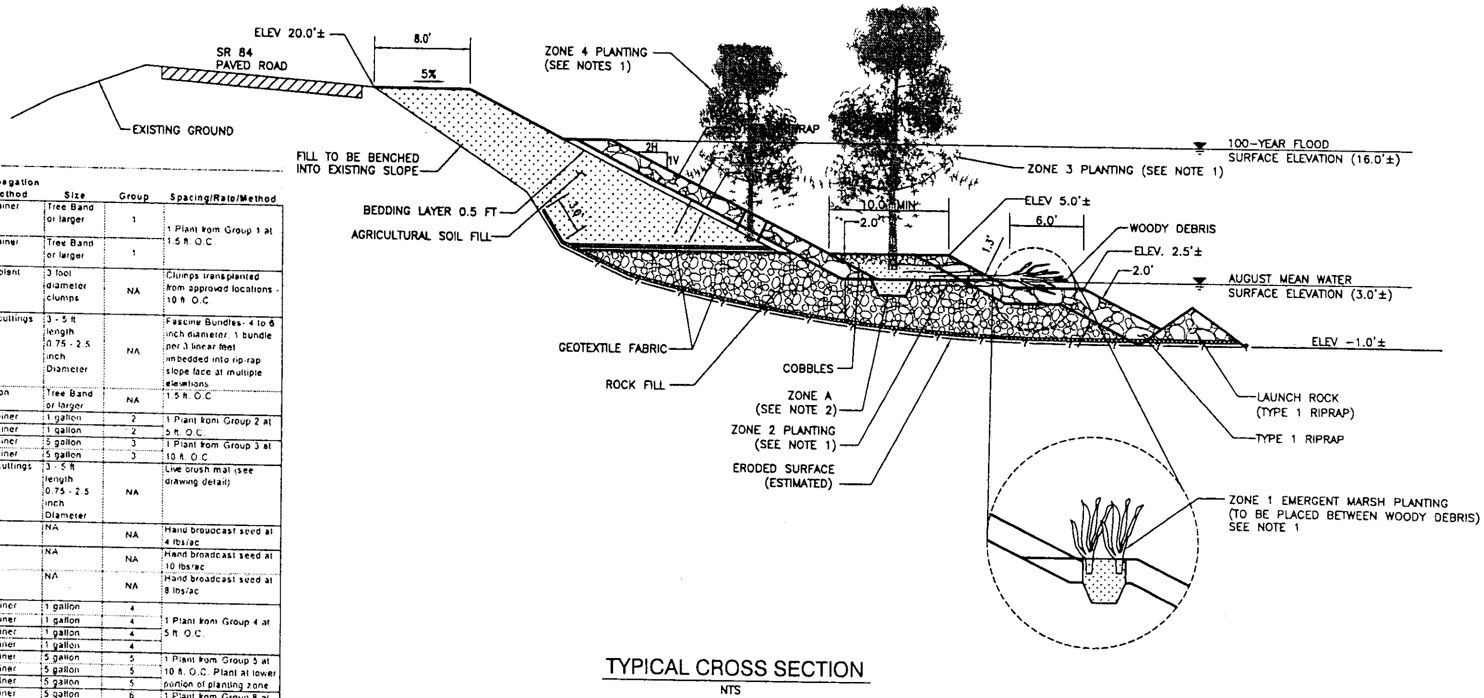


MAY 4, 2006

NOTES:

1. Four different zones of plantings are used at this site. The zones are shown in the typical cross section, and the species to be planted and their spacing are shown in the table at the left. See also Specification Section 2950.

2. After placement of rock fill in Zone 2 and riprap in Zone 4, fill gaps between rocks with planting soil to the maximum depth possible prior to planting on top.



TYPICAL CROSS SECTION

NTS

Typical Planting Schedule - DWR Levee Repair

Zone	Elevation (NGVD 29)	Botanical Name	Common Name	Propagation Method	Size	Group	Spacing/Rate/Method
1 (emergent bench)		*Scirpus acutus*	common tule	Container	Tree Band or larger	1	1 Plant from Group 1 at 1.5 ft. O.C.
		Scirpus californicus	California bulrush	Container	Tree Band or larger	1	
		Scirpus spp (includes S. acutus and/or S californicus.	bulrush/tule species	transplant	3 foot diameter clumps	NA	Clumps transplanted from approved locations - 10 ft O.C.
2 (transition slope)		*Salix spp. (includes S. laevigata, S. lasiolepis, S gooddingii, S. lucida, S exigua)*	willow species	pole cuttings	3 - 5 ft length 0.75 - 2.5 inch Diameter	NA	Fascine Bundles- 4 to 6 inch diameter, 1 bundle per 3 linear feet imbedded into rip-rap slope face at multiple elevations
3 (riparian bench)		*Leymus triticoides*	creeping wildrye	Division	Tree Band or larger	NA	1.5 ft. O.C
		Grindelia camporum	gum plant	Container	1 gallon	2	1 Plant from Group 2 at 5 ft. O.C.
		Deschampsia caespitosa	tufted hair-grass	Container	1 gallon	2	
		Populus fremontii	Fremont's cottonwood	Container	5 gallon	3	1 Plant from Group 3 at 10 ft. O.C.
		Acer negundo	boxelder	Container	5 gallon	3	
		Salix spp (includes S. laevigata, S. lasiolepis, S. gooddingii, S. lucida, S. exigua)	willow species	pole cuttings	3 - 5 ft length 0.75 - 2.5 inch Diameter	NA	Live brush mat (see drawing detail)
		Achillea millefolium	common yarrow	Seed	NA	NA	Hand broadcast seed at 4 lbs/ac
		Hordeum brachyantherum	meadow barley	Seed	NA	NA	Hand broadcast seed at 10 lbs/ac
		Artemisia douglasiana	mugwort	Seed	NA	NA	Hand broadcast seed at 8 lbs/ac
4 (levee slope)		*Rhamnus californica*	California coffeeberry	Container	1 gallon	4	1 Plant from Group 4 at 5 ft. O.C.
		Rosa californica	California rose	Container	1 gallon	4	
		Rubus ursinus	California blackberry	Container	1 gallon	4	
		Baccharis pilularis	coyote brush	Container	1 gallon	4	
		Populus fremontii	Fremont's cottonwood	Container	5 gallon	5	1 Plant from Group 5 at 10 ft. O.C. Plant at lower portion of planting zone.
		Acer negundo	box elder	Container	5 gallon	5	
		Alnus rhombifolia	white alder	Container	5 gallon	5	
		Quercus lobata	Valley oak	Container	5 gallon	6	1 Plant from Group 6 at 10 ft. O.C. Plant at higher portion of planting zone.
		Plantanus racemosa	sycamore	Container	5 gallon	6	
		Bromus carinatus	California brome	Seed	NA	NA	10 lbs/ac
		Elymus glaucus	blue wild rye	Seed	NA	NA	8 lbs/ac
		Nassella pulchra	purple needle grass	Seed	NA	NA	5 lbs/ac
		Melica californica	California barley	Seed	NA	NA	5 lbs/ac
		Achillea millefolium	Common yarrow	Seed	NA	NA	4 lbs/ac
		Aster chilensis	Common aster	Seed	NA	NA	4 lbs/ac
		Bromus carinatus	California brome	Seed	NA	NA	8 lbs/ac
		Eschscholzia californica	California poppy	Seed	NA	NA	4 lbs/ac
		Hordeum brachyantherum	meadow barley	Seed	NA	NA	4 lbs/ac
		Lupinus bicolor	minature lupine	Seed	NA	NA	8 lbs/ac

NA = Not Applicable

REV	DATE	DESCRIPTION	SUB.	APPD

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REVIEWED / DATE / APPROVAL RECOMMENDED / APPROVED PROJECT MANAGER

STATE OF CALIFORNIA
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DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
FLOOD MANAGEMENT

STATE EMERGENCY EROSION REPAIR PROJECT
EMERGENCY LEVEE EROSION REPAIR

SITE 38CAS 16.5L TYPICAL SECTION

SPEC NO.
DRAWING NO. C-05
REV. SHEET NO. 005

Figure 14
Typical Cross Section at Cache Slough, RM 16.5

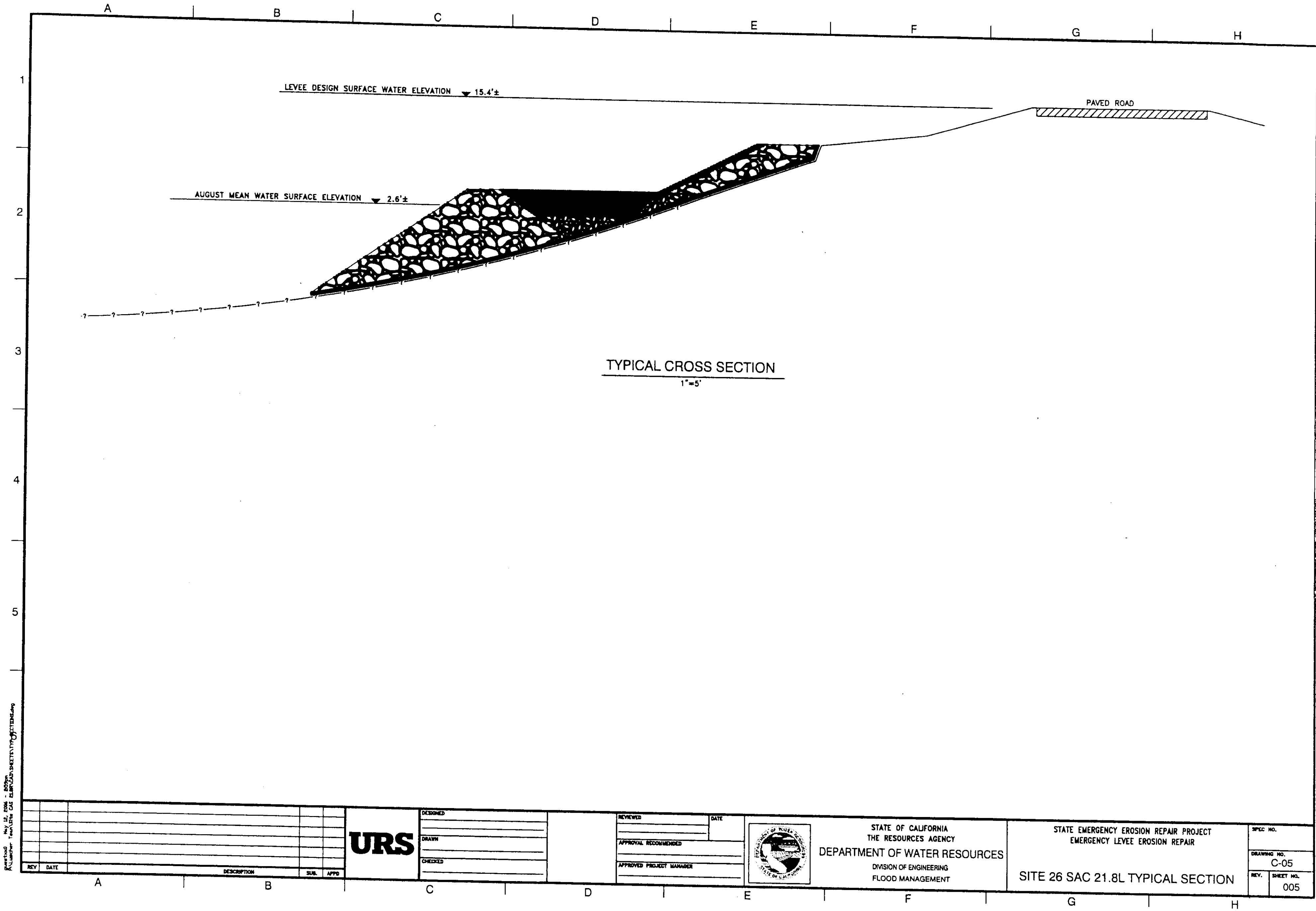
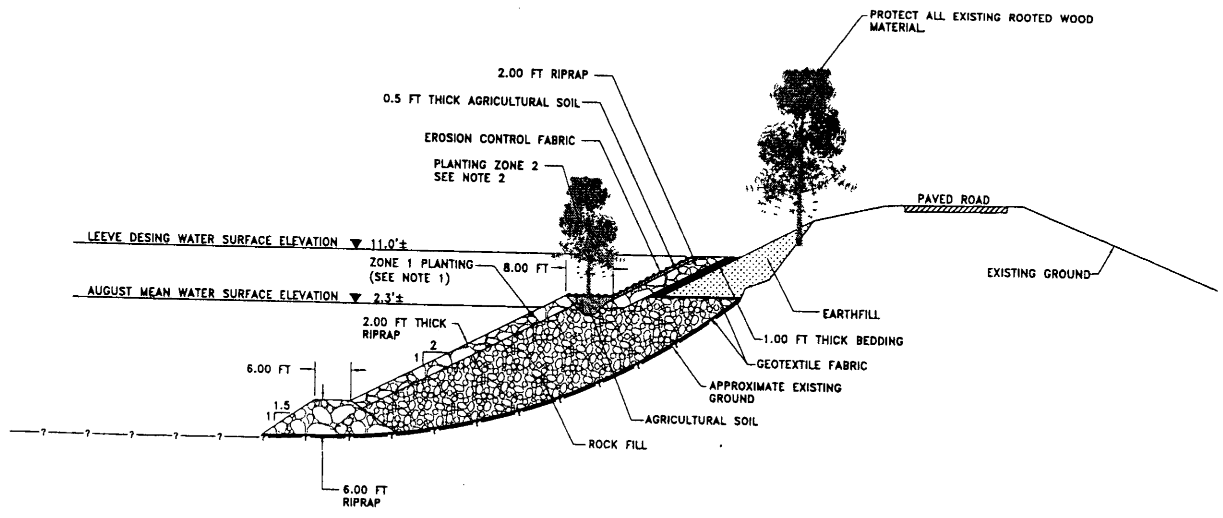


Figure 15
Typical Cross Section at Cache Slough, RM 21.8



TYPICAL CROSS SECTION

1"=10'

NOTE:

1. VARY TOP ELEVATION OF RIPARIAN BENCH BY +/- 1 FOOT FROM SPECIFIED MEAN ELEVATION IN 40- TO 80-FOOT-LONG IRREGULAR UNDULATIONS.
2. ZONE 1 (REPAIRED SLOPES FROM 2 FEET BELOW TO 2 FEET ABOVE RIPARIAN BENCH) PLANTINGS TO BE VARIOUS TYPES OF WILLOWS AS SPECIFIED IN "TYPICAL PLANTING SCHEDULE" ON THIS SHEET. SEE ALSO SPECIFICATION SECTION 2950
3. ZONE 2 (RIPARIAN BENCH) PLANTING TO CONSIST OF A MIX OF PLANTS AS SPECIFIED IN TABLE "TYPICAL PLANTING SCHEDULE".
4. ZONE 3 (LEVEE SLOPE ABOVE BENCH) PLANTING TO CONSIST OF A MIX OF VARIOUS TYPES OF GRASS SEEDS AND SMALL SHRUBS AS SPECIFIED IN TABLE "TYPICAL PLANTING SCHEDULE".
5. GAPS IN ROCK FILL UNDER RIPARIAN BENCH TO BE FILLED WITH AGRICULTURAL SOIL TO MAXIMUM EXTENT AND DEPTH PRACTICAL BEFORE PLACING OVERLYING AGRICULTURAL SOIL FILL.

REV	DATE	DESCRIPTION	SUB.	APPD

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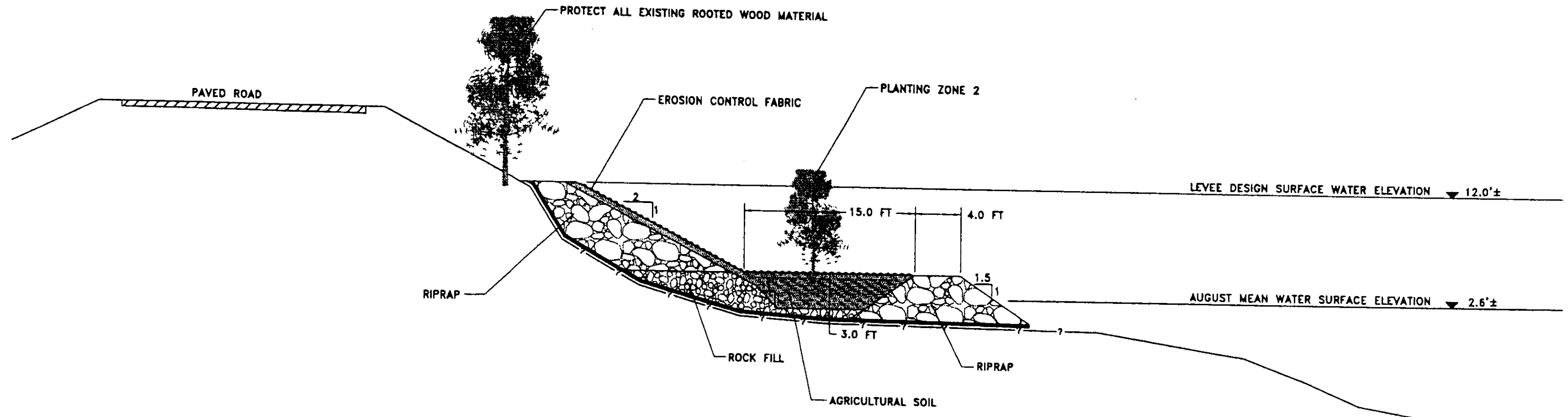
EMERGENCY LEVEE EROSION REPAIR

SITE 24 STE 16.2R TYPICAL SECTION

SPEC NO.
DRAWING NO. C-05
REV. | SHEET NO. 005

Figure 16
Typical Cross Section at Sacramento River, RM 16.2



TYPICAL CROSS SECTION
1"=5'

NOTE:

1. THE EXISTING ROCK FILL BETWEEN ABOUT STA 3+60 AND 2+50 SHALL BE REMOVED DOWN TO THE SPECIFIED TOP OF ROCK FILL ELEVATION.
2. THE FINISHED ELEVATION OF THE TOP OF THE RIPARIAN BENCH SHALL BE VARIED BY ±1.0 FOOT IN LONG (100 TO 200 FEET) IRREGULAR UNDULATIONS ALONG THE BENCH.
3. THE TOP PART OF THE EXISTING LEVEE SLOPE ABOVE THE TOP OF THE RIPRAP AT ELEATION 14.6 FEET SHALL BE PROTECTED FROM ANY CONSTRUCTION DISTURBANCE.
4. EXISTING TREES AND LARGER SHRUBS BELOW ELEVATION 14.6 FEET SHALL BE LEFT IN PLACE AND PROTECTED FROM CONSTRUCTION DAMAGE. TREES SHALL BE PROTECTED FROM DIRECT CONTACT WITH LARGE ROCKS, AND FILL MATERIAL SHALL BE PLACED CAREFULLY (BY HAND IF REQUIRED) AROUND THE TREE TRUNKS.
5. GAPS IN ROCK FILL UNDER RIPARIAN BENCH AND IN RIPRAP UNDER UPPER LEVEE SLOPE SHALL BE FILLED WITH SOIL IN MAXIMUM EXTENT AND DEPTH PRACTICAL BEFORE PLACING OVERLYING SOIL FILL.
6. ZONE 2 (ABOUT 2 FEET ABOVE AND BELOW RIPARIAN BENCH) PLANTING TO CONSIST OF WILLOW BRANCHES PLACED INTO RIPRAP AS SPECIFIED IN TABLE AT LEFT.
7. ZONE 3 (RIPARIAN BENCH) PLANTING TO CONSIST OF A MIX OF TREES AND SHRUBS AS SPECIFIED IN THE TABLE AT LEFT.
8. ZONE 4 (LEVEE SLOPE ABOVE BENCH) PLANTING TO CONSIST OF A MIX OF VARIOUS TYPES OF GRASS SEEDS AND SMALL SHRUBS AS SPECIFIED IN THE TABLE AT LEFT.

REV	DATE	DESCRIPTION	SUB.	APPD

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EMERGENCY LEVEE EROSION REPAIR

SITE 26 SAC 20.8L TYPICAL SECTION

SPEC NO.
DRAWING NO. C-05
REV. SHEET NO. 005

Figure 17
Typical Cross Section at Sacramento River, RM 20.8

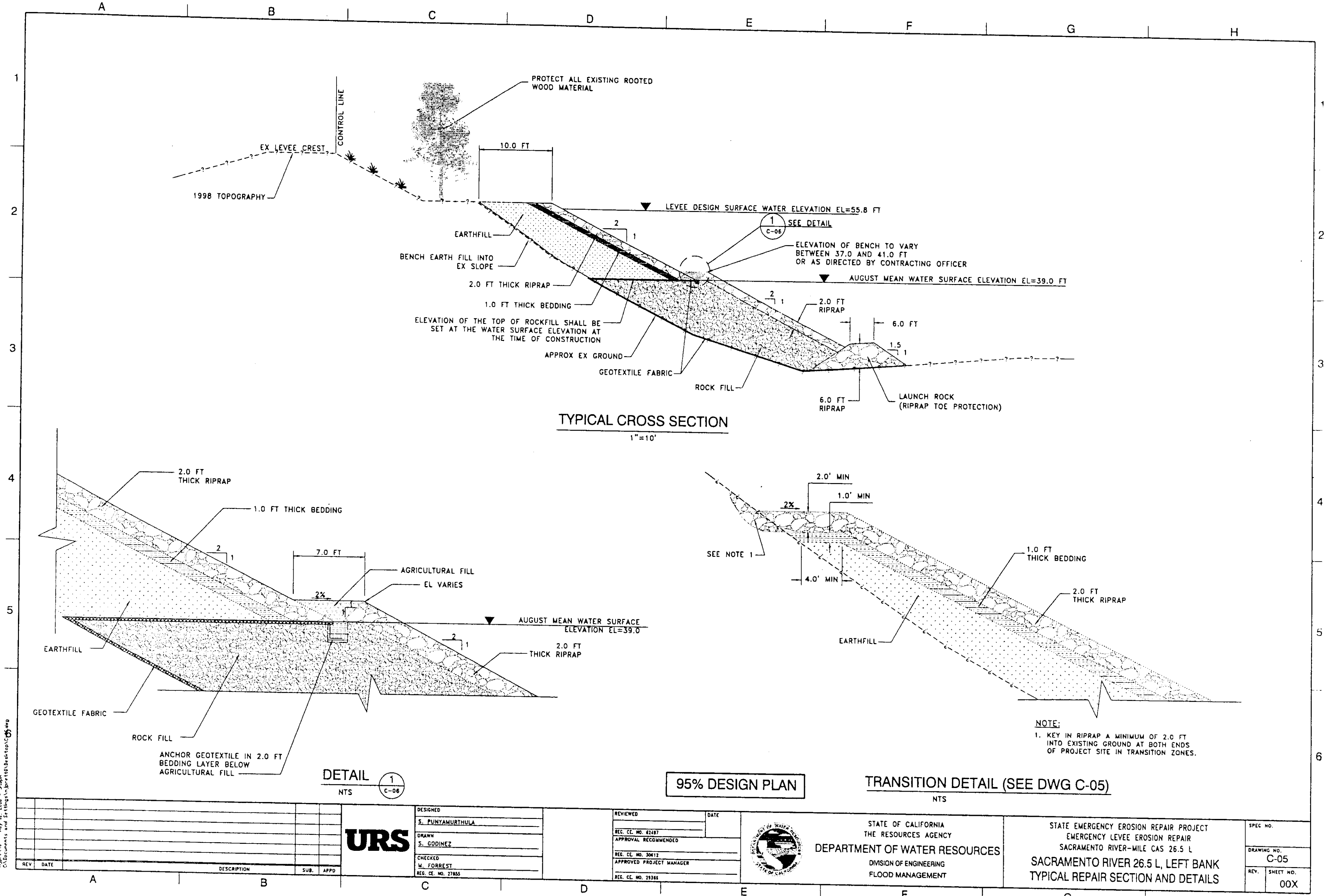

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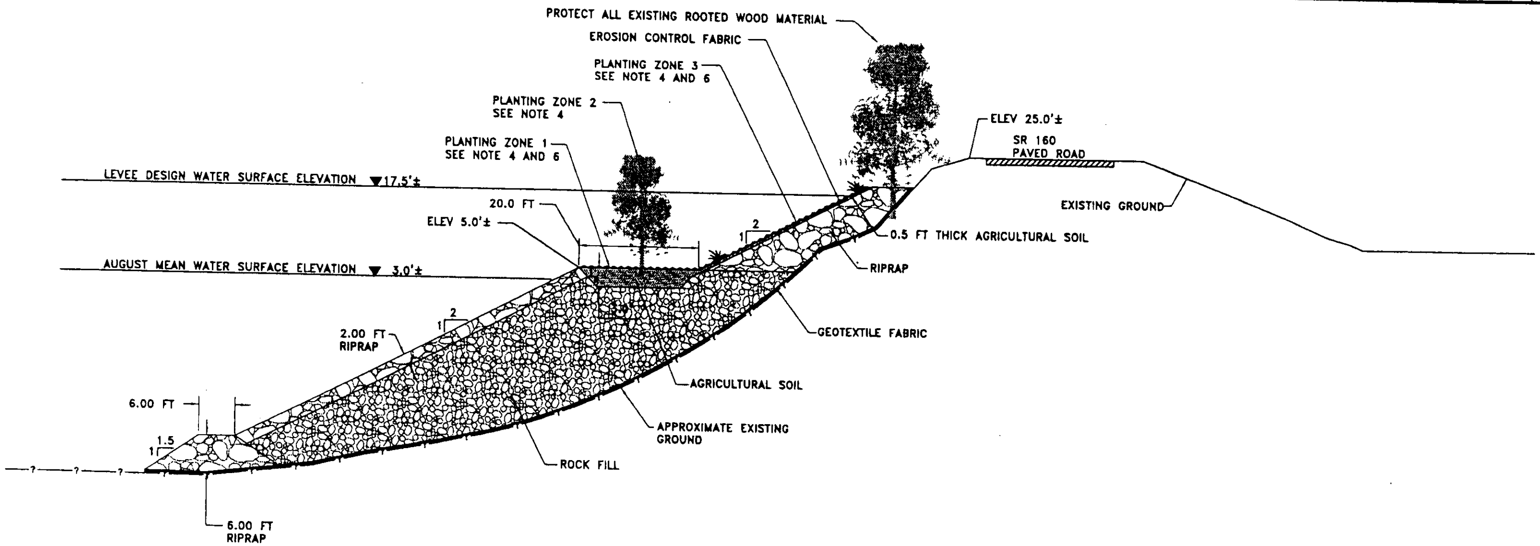
Figure 18
Typical Cross Section at Sacramento River, RM 26.5



TYPICAL CROSS SECTION

1"=10'

NOTE:

1. VARY TOP ELEVATION OF RIPARIAN BENCH BY +/- 1 FOOT FROM SPECIFIED MEAN ELEVATION IN 100- TO 200-FOOT-LONG IRREGULAR UNDULATIONS.
2. ALSO VARY HORIZONTAL ALIGNMENT OF BOTH UPPER AND LOWER LEVEE SLOPES BY +/- 5 FEET IN LONG IRREGULAR UNDULATIONS.
3. EXISTING TREES AND LARGER SHRUBS ON THE LEVEE SLOPE SHALL BE LEFT IN PLACE AND PROTECTED FROM CONSTRUCTION DAMAGE. TREES SHALL BE PROTECTED FROM DIRECT CONTACT WITH LARGE ROCKS, AND FILL SHALL BE PLACED CAREFULLY (BY HAND IF REQUIRED) AROUND THE TREE TRUNKS.
4. THREE ZONES OF PLANTINGS ARE USED AT THIS SITE, ZONES 1, 2 AND 3. THE ZONES ARE SHOWN IN THE TYPICAL CROSS SECTION, AND THE SPECIES TO BE PLANTED AND THEIR SPACINGS ARE SHOWN IN THE TABLE "TYPICAL PLANTING SCHEDULE" ON THIS SHEET. SEE ALSO SPECIFICATIONS SECTION 2950.
5. AFTER PLACEMENT OF ROCK FILL IN ZONE 1, FILL GAPS BETWEEN ROCKS WITH AGRICULTURAL SOIL TO MAXIMUM DEPTH PRACTICAL PRIOR TO PLACING AGRICULTURAL SOIL FILL AND PLANTING.
6. PROTECT SOIL SURFACES IN ZONES 1 AND 3 BY PLACING EROSION CONTROL FABRIC ON SURFACE.

REV	DATE	DESCRIPTION	SUB.	APP'D

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DIVISION OF ENGINEERING
FLOOD MANAGEMENT

STATE EMERGENCY EROSION REPAIR PROJECT
EMERGENCY LEVEE EROSION REPAIR

SITE 2 SAC 32.5R TYPICAL SECTION

SPEC NO.
DRAWING NO. C-05
REV. SHEET NO. 005

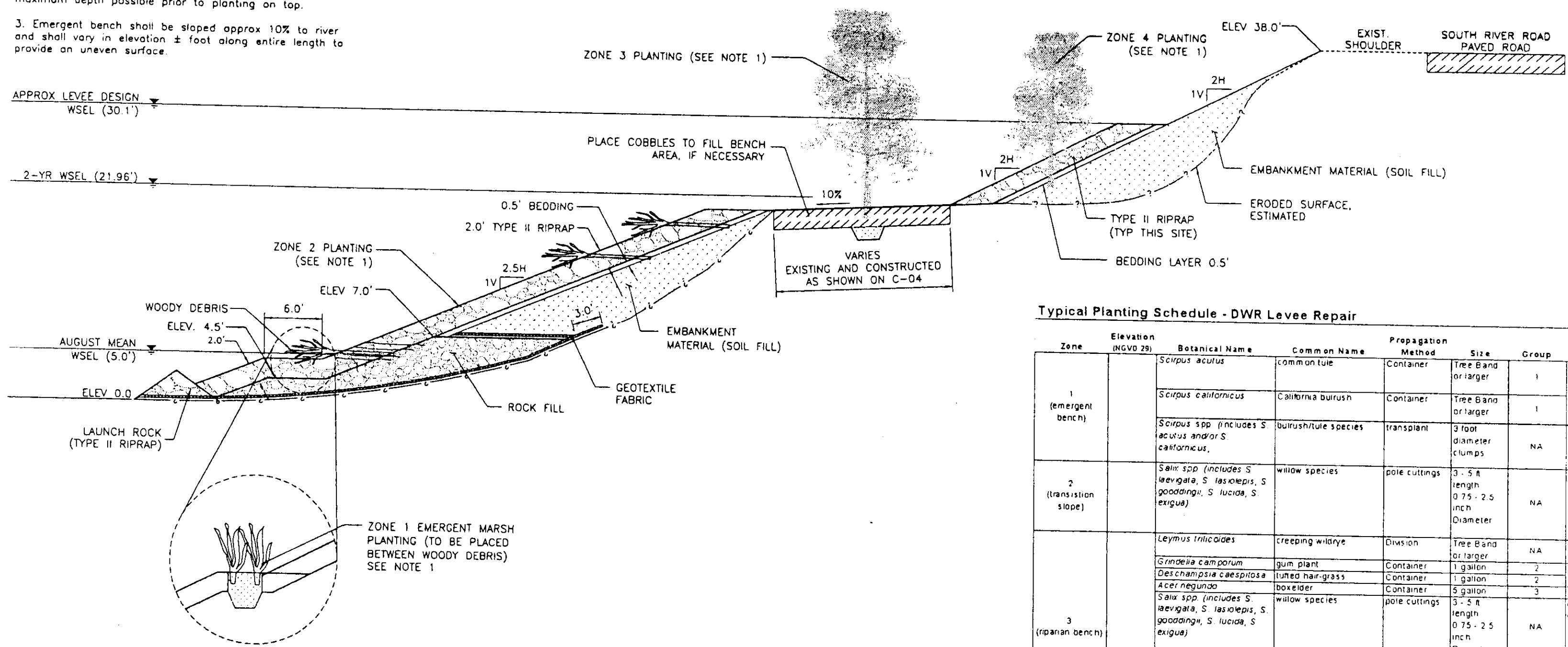
Figure 19
Typical Cross Section at Sacramento River, RM 32.5

NOTES:

1. Four different zones of plantings are used at this site. The zones are shown in the typical cross section, and the species to be planted and their spacing are shown in the table at the left. See also Specification Section 2950.

2. After placement of rock fill in Zone 2 and riprap in Zone 4, fill gaps between rocks with planting soil to the maximum depth possible prior to planting on top.

3. Emergent bench shall be sloped approx 10% to river and shall vary in elevation ± foot along entire length to provide an uneven surface.



TYPICAL CROSS SECTION

NTS

Typical Planting Schedule - DWR Levee Repair

Zone	Elevation (NGVD 29)	Botanical Name	Common Name	Propagation Method	Size	Group	Spacing/Rate/Method
1 (emergent bench)		*Scirpus acutus*	common tule	Container	Tree Band or larger	1	1 Plant from Group 1 at 1.5 ft. O.C.
		Scirpus californicus	California bulrush	Container	Tree Band or larger	1	
		Scirpus spp. (includes *S. acutus* and/or *S. californicus*,	bulrush/tule species	transplant	3 foot diameter clumps	NA	Clumps transplanted from approved locations - 10 ft. O.C.
2 (transistion slope)		*Salix* spp. (includes *S. laevigata*, *S. lasiolepis*, *S. gooddingii*, *S. lucida*, *S. exigua*)	willow species	pole cuttings	3 - 5 ft length 0.75 - 2.5 inch Diameter	NA	Fascine Bundles- 4 to 6 inch diameter, 1 bundle per 3 linear feet imbedded into rip-rap slope face at multiple elevations
3 (riparian bench)		*Leymus triticoides*	creeping wildrye	Division	Tree Band or larger	NA	1.5 ft. O.C.
		Grindelia camporum	gum plant	Container	1 gallon	2	1 Plant from Group 2 at 5 ft. O.C.
		Deschampsia caespitosa	tufted hair-grass	Container	1 gallon	2	
		Acer negundo	boxelder	Container	5 gallon	3	
		Salix spp. (includes *S. laevigata*, *S. lasiolepis*, *S. gooddingii*, *S. lucida*, *S. exigua*)	willow species	pole cuttings	3 - 5 ft length 0.75 - 2.5 inch Diameter	NA	Live brush mat (see drawing detail)
		Achillea millefolium	common yarrow	Seed	NA	NA	Hand broadcast seed at 4 lbs/ac
		Hordeum brachyantherum	meadow barley	Seed	NA	NA	Hand broadcast seed at 10 lbs/ac
		Artemisia douglasiana	mugwort	Seed	NA	NA	Hand broadcast seed at 8 lbs/ac
4 (levee slope)		*Rhamnus californica*	California coffeeberry	Container	1 gallon	4	1 Plant from Group 4 at 5 ft. O.C.
		Rosa californica	California rose	Container	1 gallon	4	
		Rubus ursinus	California blackberry	Container	1 gallon	4	
		Baccharis pilularis	coyote brush	Container	1 gallon	4	
		Populus fremontii	Fremont's cottonwood	Container	5 gallon	5	1 Plant from Group 5 at 10 ft. O.C. Plant at lower portion of planting zone.
		Acer negundo	box elder	Container	5 gallon	5	
		Alnus rhombifolia	white alder	Container	5 gallon	5	
		Quercus lobata	Valley oak	Container	5 gallon	6	1 Plant from Group 6 at 10 ft. O.C. Plant at higher portion of planting zone
		Plantanus racemosa	sycamore	Container	5 gallon	6	
		Bromus carinatus	California brome	Seed	NA	NA	10 lbs/ac
		Elymus glaucus	blue wild rye	Seed	NA	NA	8 lbs/ac
		Nassella pulchra	purple needle grass	Seed	NA	NA	5 lbs/ac
		Melica californica	California barley	Seed	NA	NA	5 lbs/ac
		Achillea millefolium	Common yarrow	Seed	NA	NA	4 lbs/ac
		Aster chilensis	Common aster	Seed	NA	NA	4 lbs/ac
		Bromus carinatus	California brome	Seed	NA	NA	8 lbs/ac
		Eschsholzia californica	California poppy	Seed	NA	NA	4 lbs/ac
		Hordeum brachyantherum	meadow barley	Seed	NA	NA	4 lbs/ac
		Lupinus bicolor	minature lupine	Seed	NA	NA	8 lbs/ac

NA = Not Applicable

REV	DATE	DESCRIPTION	SUB.	APPD

DESIGNED	REVIEWED	DATE
W. ZIRJACKS		MAY 01, 2006
DRAWN	APPROVAL RECOMMENDED	
L.O. BERNALDEZ		
CHECKED	APPROVED PROJECT MANAGER	

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DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
FLOOD MANAGEMENT

SACRAMENTO RIVER FLOOD CONTROL PROJECT
EMERGENCY LEVEE EROSION REPAIR
SITE SAC 56.8R TYPICAL SECTION

SPEC NO.
DRAWING NO. C-05
REV. SHEET NO. 005

May 06, 2006 - 4:47pm
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Figure 20
Typical Cross Section at Sacramento River, RM 56.8

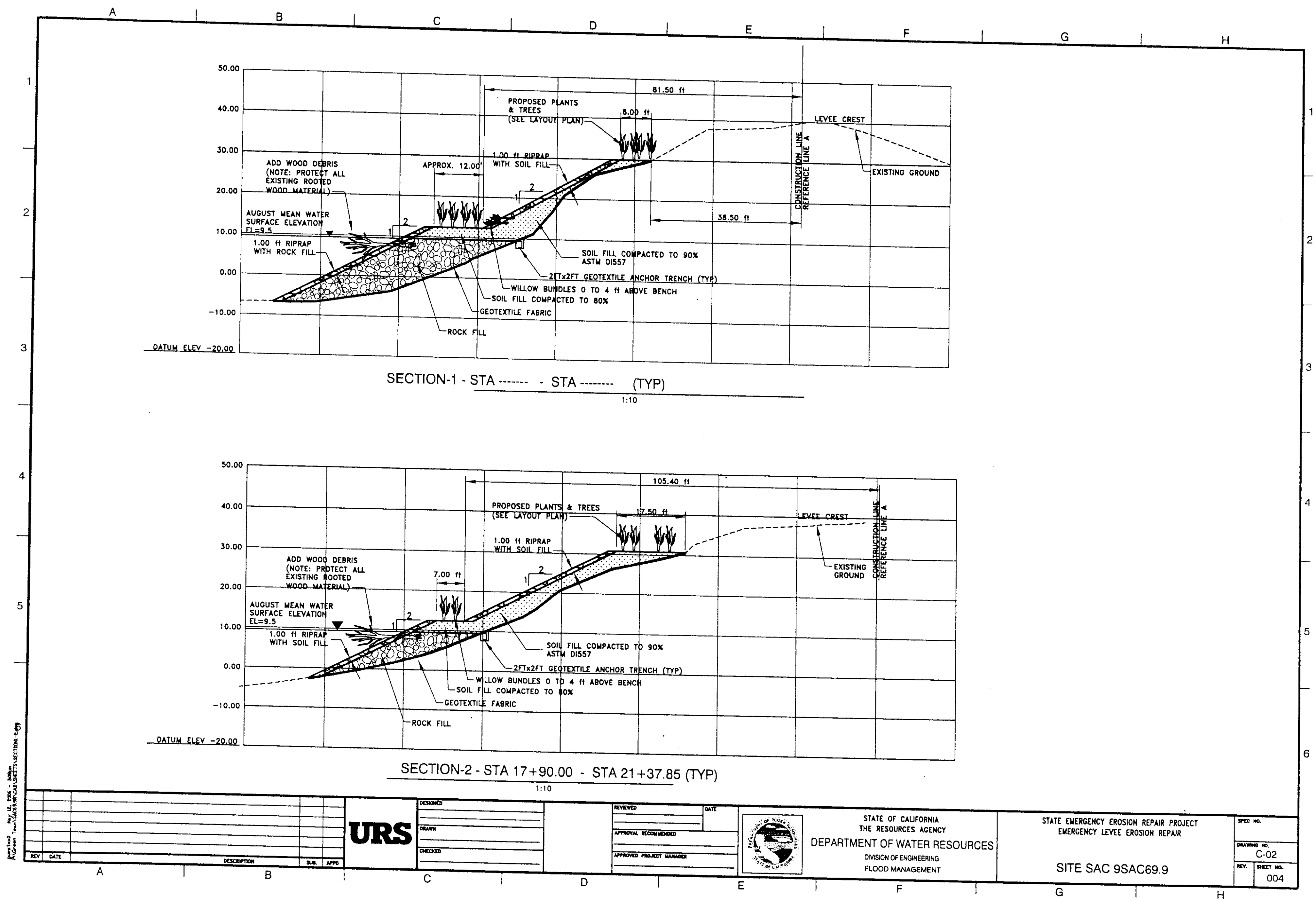


Figure 21
Typical Cross Section at Sacramento River, RM 69.9

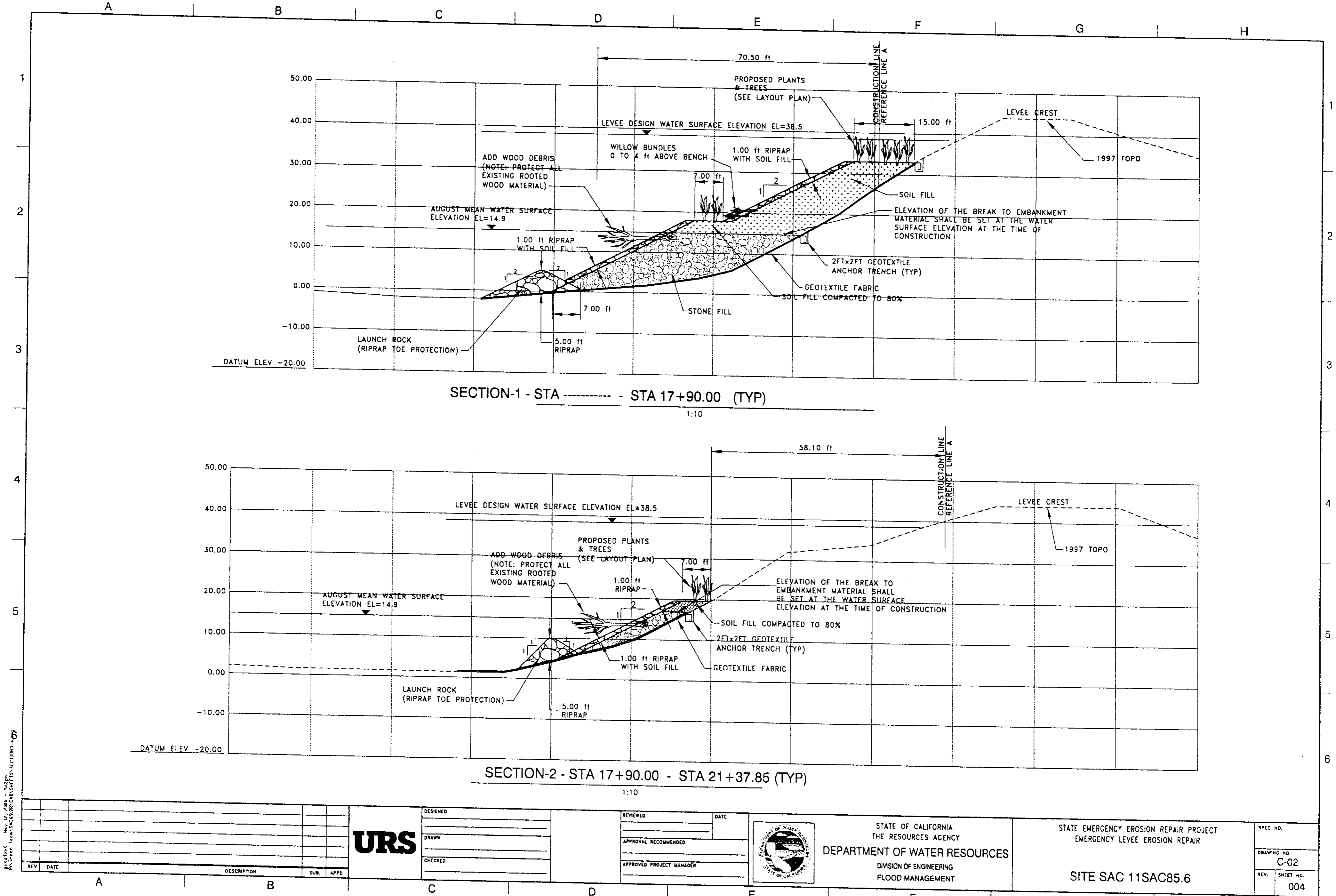
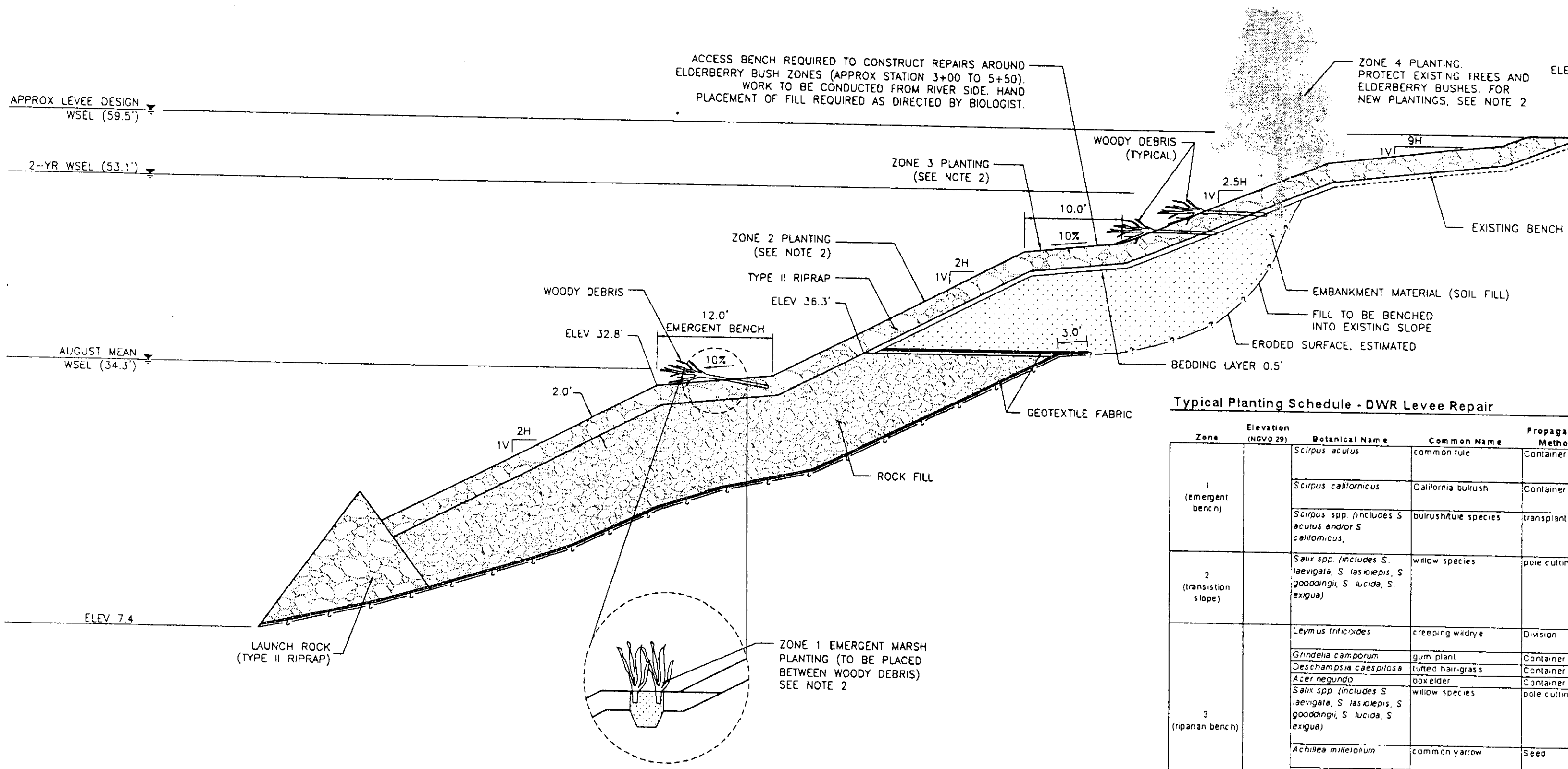


Figure 22
Typical Cross Section at Sacramento River, RM 85.6



TYPICAL CROSS SECTION

NTS

NOTES:

1. Emergent bench shall be sloped approx 10% to river and shall vary in elevation ± foot along entire length to provide an uneven surface.

2. Four different zones of plantings are used at this site. The zones are shown in the typical cross section, and the species to be planted and their spacing are shown in the table at the left. See also Specification Section 2950.

3. After placement of rock fill in Zone 2 and riprap in Zone 4, fill gaps between rocks with planting soil to the maximum depth possible prior to planting on top.

Typical Planting Schedule - DWR Levee Repair

Zone	Elevation (NGVD 29)	Botanical Name	Common Name	Propagation Method	Size	Group	Spacing/Rate/Method
1 (emergent bench)		*Scirpus acutus*	common tule	Container	Tree Band or larger	1	1 Plant from Group 1 at 1.5 ft. O.C.
		Scirpus californicus	California bulrush	Container	Tree Band or larger	1	
		Scirpus spp. (includes S. acutus and/or S. californicus,	bulrush/tule species	transplant	3 foot diameter clumps	NA	Clumps transplanted from approved locations - 10 ft. O.C.
2 (transistion slope)		*Salix spp. (includes S. laevigata, S. lasiolepis, S. gooddingii, S. lucida, S. exigua)*	willow species	pole cuttings	3 - 5 ft length 0.75 - 2.5 inch Diameter	NA	Fascine Bundles- 4 to 6 inch diameter, 1 bundle per 3 linear feet imbedded into rip-rap slope face at multiple elevations.
3 (riparian bench)		*Leymus triticoides*	creeping wildrye	Division	Tree Band or larger	NA	1.5 ft. O.C.
		Grindelia camporum	gum plant	Container	1 gallon	2	1 Plant from Group 2 at 5 ft. O.C.
		Deschampsia caespitosa	tufted hair-grass	Container	1 gallon	2	
		Acer negundo	boxelder	Container	5 gallon	3	
		Salix spp. (includes S. laevigata, S. lasiolepis, S. gooddingii, S. lucida, S. exigua)	willow species	pole cuttings	3 - 5 ft length 0.75 - 2.5 inch Diameter	NA	Live brush mat (see drawing detail)
		Achillea millefolium	common yarrow	Seed	NA	NA	Hand broadcast seed at 4 lbs/ac
		Hordeum brachyantherum	meadow barley	Seed	NA	NA	Hand broadcast seed at 10 lbs/ac
		Artemisia douglasiana	mugwort	Seed	NA	NA	Hand broadcast seed at 8 lbs/ac
4 (levee slope and bench)		*Rhamnus californica*	California coffeeberry	Container	1 gallon	4	1 Plant from Group 4 at 5 ft. O.C.
		Rosa californica	California rose	Container	1 gallon	4	
		Rubus ursinus	California blackberry	Container	1 gallon	4	
		Baccharis pilularis	coyote brush	Container	1 gallon	4	
		Populus fremontii	Fremont's cottonwood	Container	5 gallon	5	1 Plant from Group 5 at 10 ft. O.C. Plant at lower portion of planting zone
		Acer negundo	box elder	Container	5 gallon	5	
		Alnus rhombifolia	white alder	Container	5 gallon	5	
		Quercus lobata	Valley oak	Container	5 gallon	6	1 Plant from Group 6 at 10 ft. O.C. Plant at higher portion of planting zone
		Plantanus racemosa	sycamore	Container	5 gallon	6	
		Bromus carinatus	California brome	Seed	NA	NA	10 lbs/ac
		Elymus glaucus	blue wild rye	Seed	NA	NA	8 lbs/ac
		Nassella pulchra	purple needle grass	Seed	NA	NA	5 lbs/ac
		Melica californica	California barley	Seed	NA	NA	5 lbs/ac
		Achillea millefolium	Common yarrow	Seed	NA	NA	4 lbs/ac
		Aster chilensis	Common aster	Seed	NA	NA	4 lbs/ac
		Bromus carinatus	California brome	Seed	NA	NA	8 lbs/ac
		Eschsholzia californica	California poppy	Seed	NA	NA	4 lbs/ac
		Hordeum brachyantherum	meadow barley	Seed	NA	NA	4 lbs/ac
		Lupinus bicolor	minature lupine	Seed	NA	NA	8 lbs/ac

NA = Not Applicable

DESIGNED M.S. BURNETT	REVIEWED	DATE MAY 01, 2006	
DRAWN L.O. BERNALDEZ	APPROVAL RECOMMENDED		
CHECKED	APPROVED PROJECT MANAGER		

REV | DATE | DESCRIPTION | SUB. | APPD

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DIVISION OF ENGINEERING
FLOOD MANAGEMENT

SACRAMENTO RIVER FLOOD CONTROL PROJECT
EMERGENCY LEVEE EROSION REPAIR
SITE SAC 130.8R TYPICAL SECTION

SPEC NO.
DRAWING NO. C-05
REV. SHEET NO. 005

May 06, 2006 - 5:38pm
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Figure 23
Typical Cross Section at Sacramento River, RM 130.8

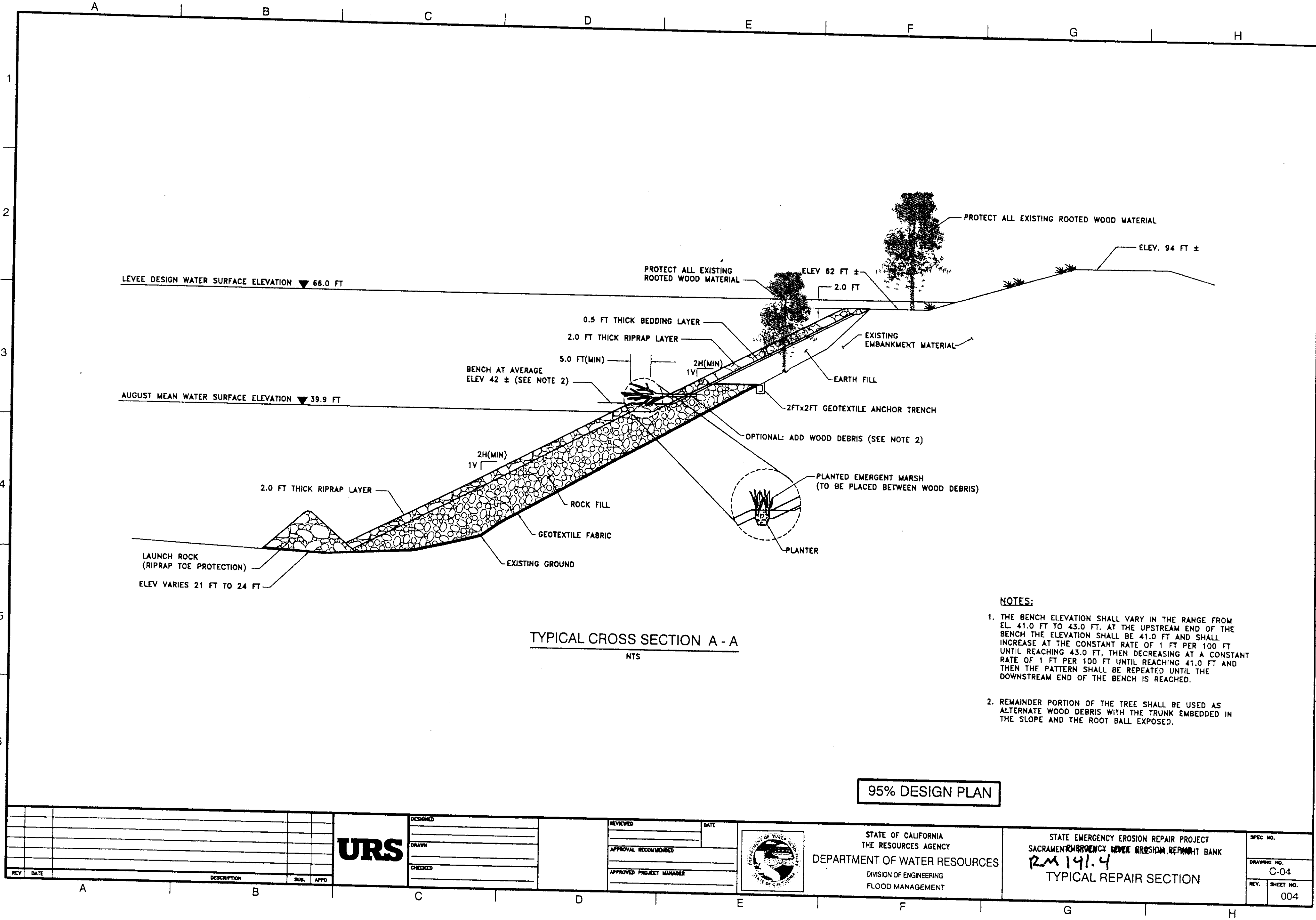


Figure 24
Typical Cross Section at Sacramento River, RM 141.4

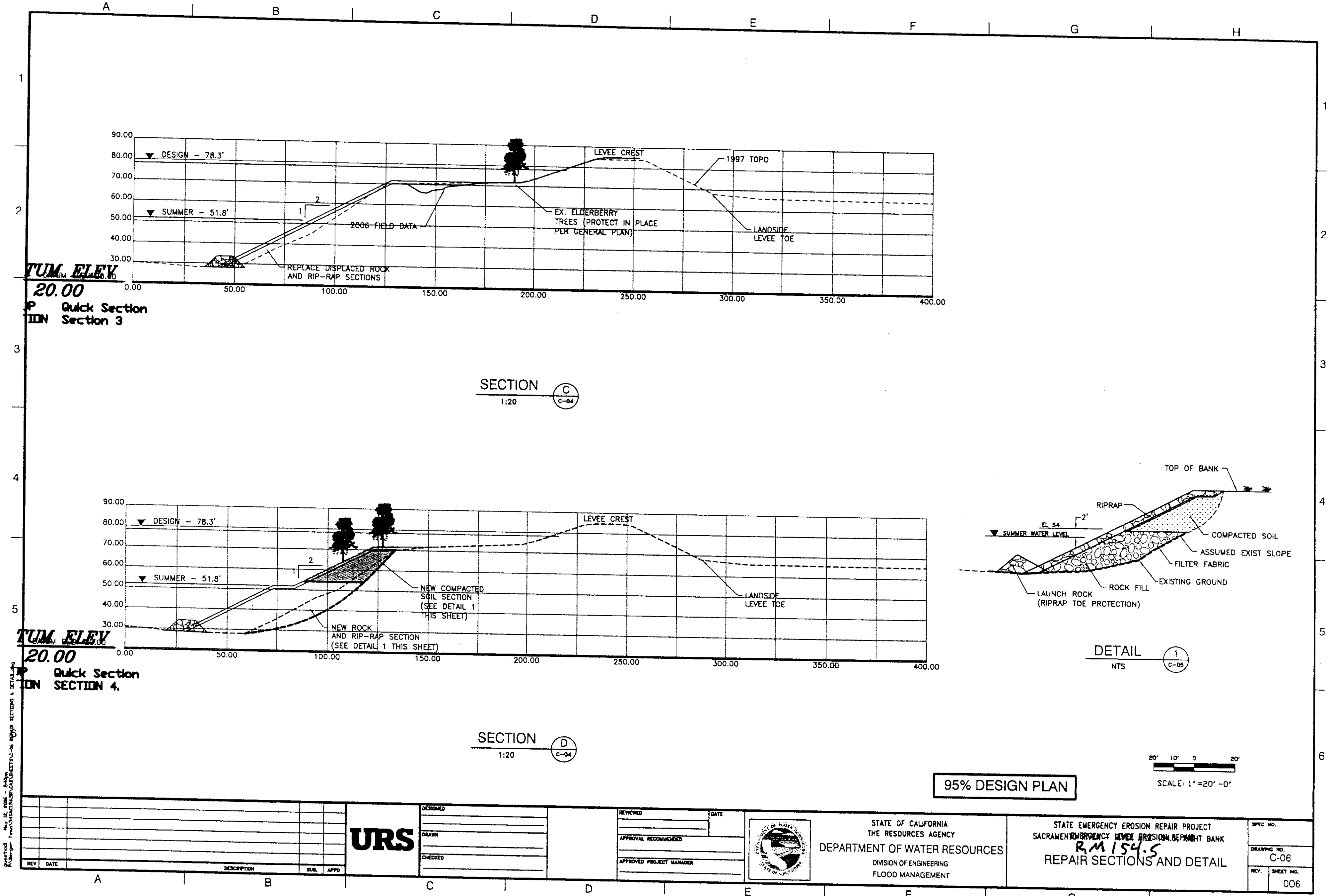
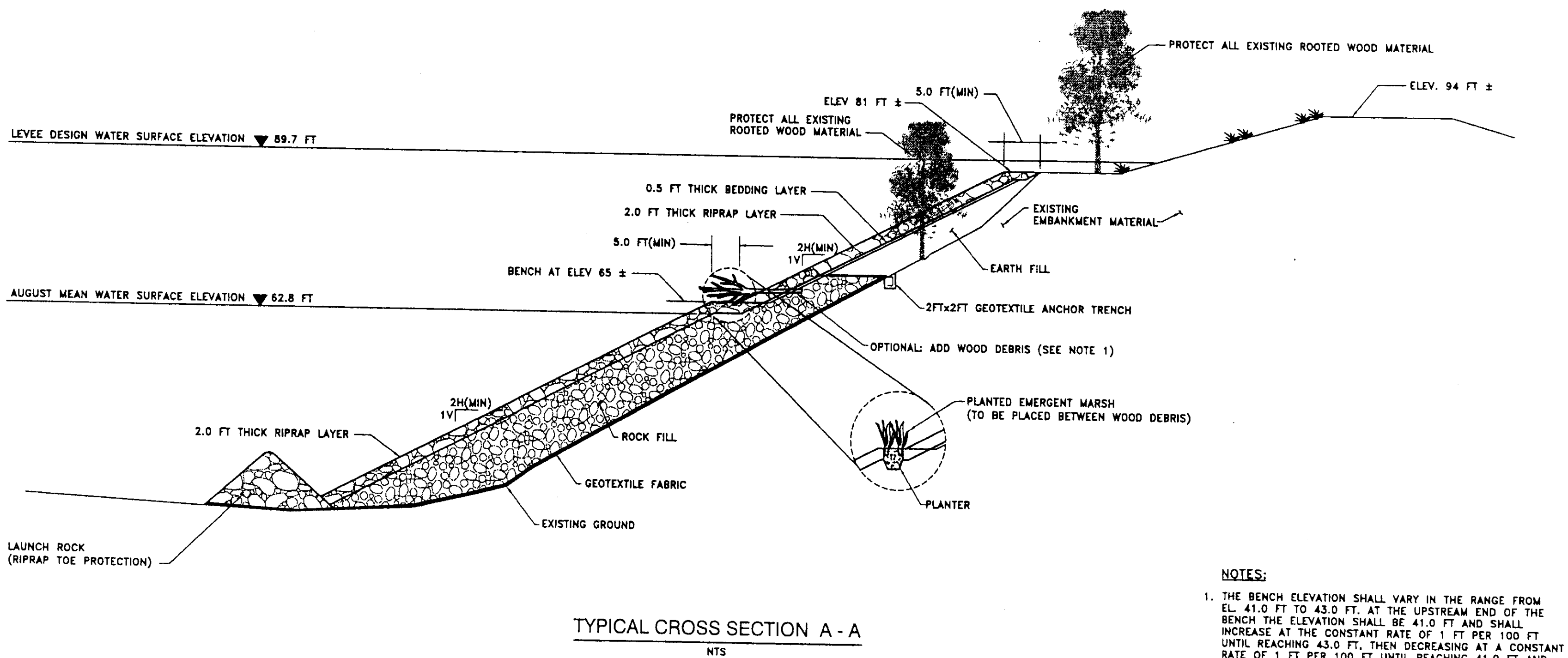


Figure 25
Typical Cross Section at Sacramento River, RM 154.5



NOTES:

1. THE BENCH ELEVATION SHALL VARY IN THE RANGE FROM EL. 41.0 FT TO 43.0 FT. AT THE UPSTREAM END OF THE BENCH THE ELEVATION SHALL BE 41.0 FT AND SHALL INCREASE AT THE CONSTANT RATE OF 1 FT PER 100 FT UNTIL REACHING 43.0 FT, THEN DECREASING AT A CONSTANT RATE OF 1 FT PER 100 FT UNTIL REACHING 41.0 FT AND THEN THE PATTERN SHALL BE REPEATED UNTIL THE DOWNSTREAM END OF THE BENCH IS REACHED.

2. REMAINDER PORTION OF THE TREE SHALL BE USED AS ALTERNATE WOOD DEBRIS WITH THE TRUNK EMBEDDED IN THE SLOPE AND THE ROOT BALL EXPOSED.

95% DESIGN PLAN

REV	DATE	DESCRIPTION	SUB.	APPD

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DIVISION OF ENGINEERING
FLOOD MANAGEMENT

STATE EMERGENCY EROSION REPAIR PROJECT
SACRAMENTO RIVER LEVEE EROSION RIGHT BANK
RM 164.0
TYPICAL REPAIR SECTION

SPEC NO.
DRAWING NO. C-04
REV. SHEET NO. 004

Figure 26
Typical Cross Section at Sacramento River, RM 164

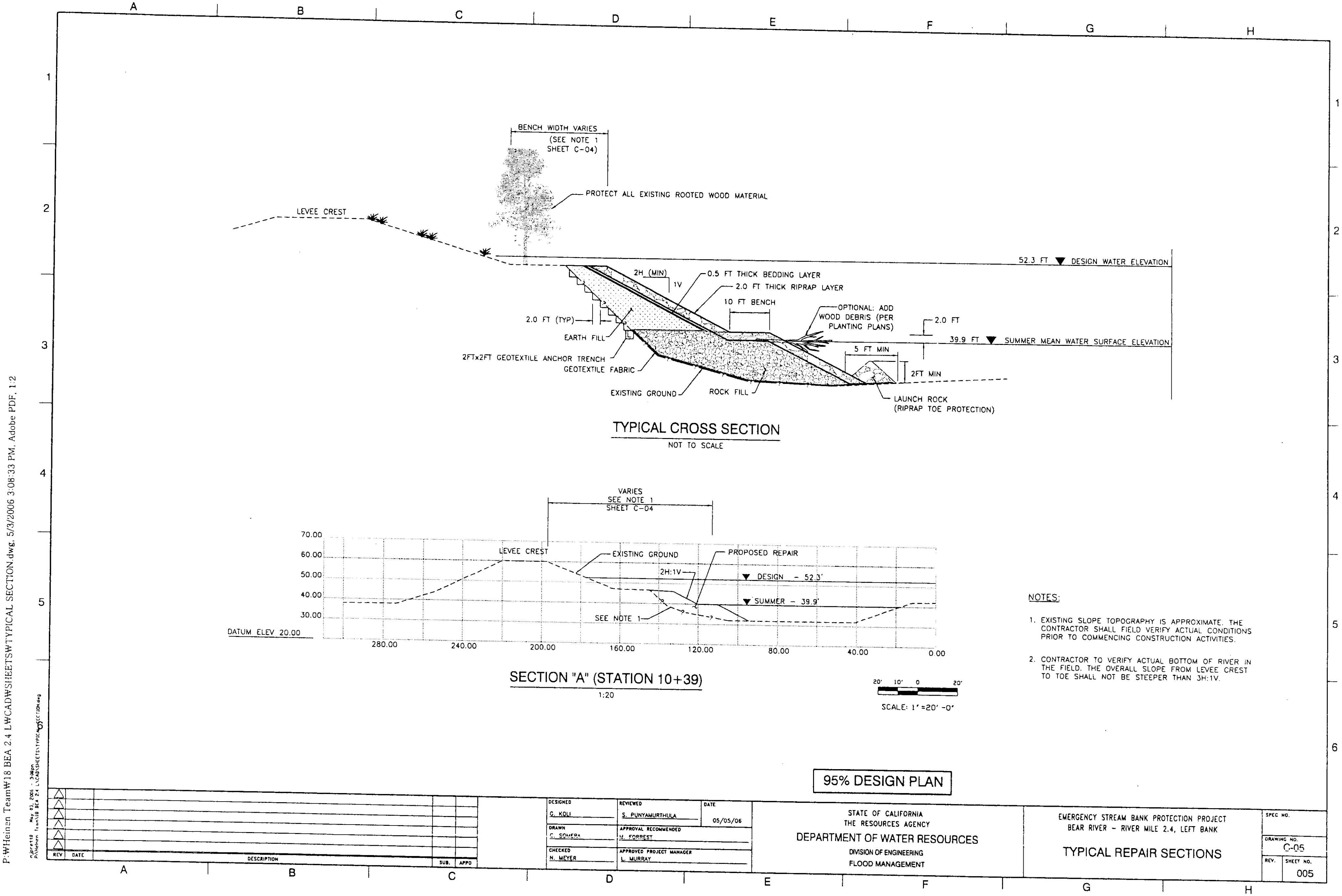
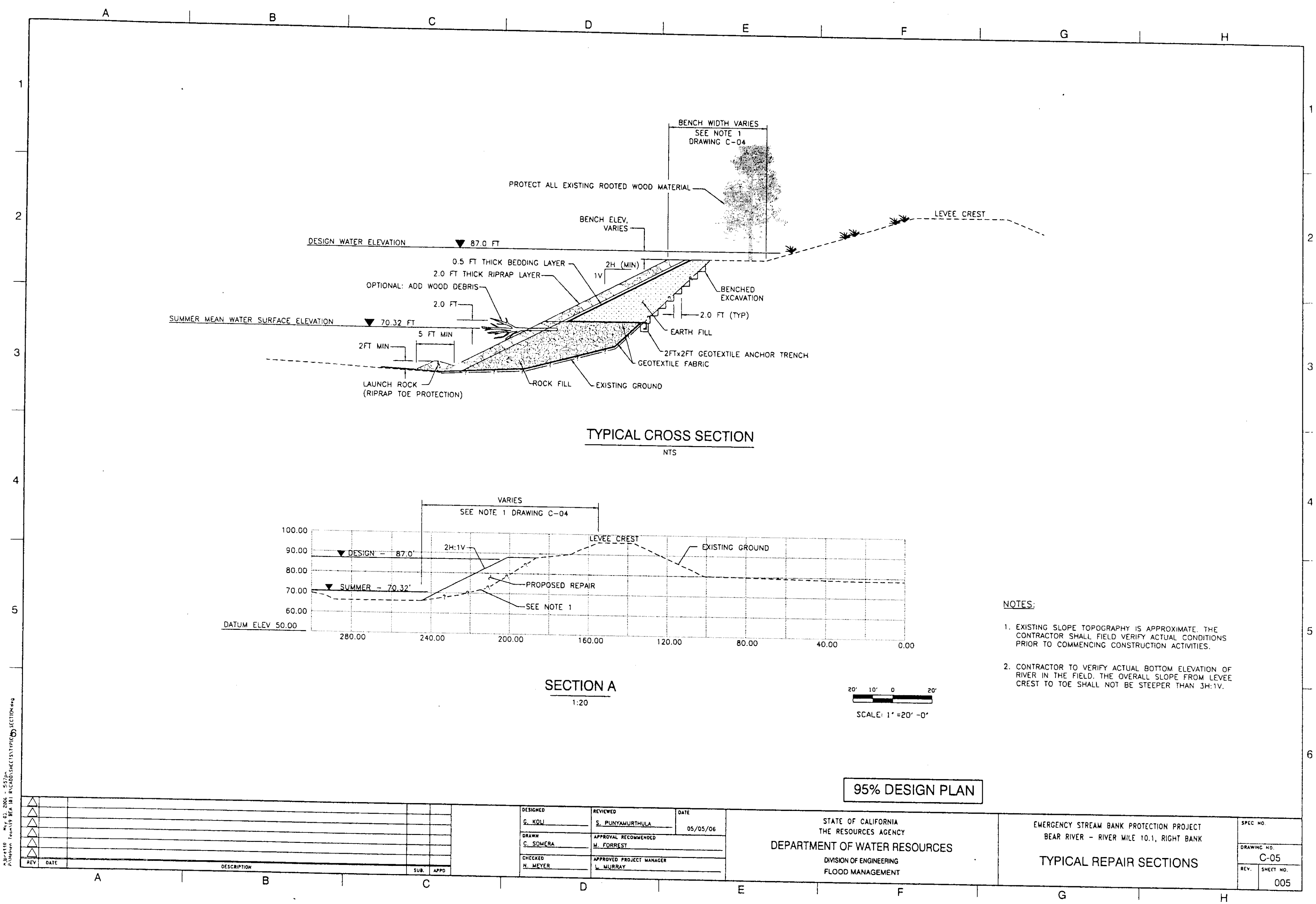


Figure 27
Typical Cross Section at Bear River, RM 2.4



P:\Heinen Team\19 BEA 10.1 R\CADD\SHEETS\TYPICAL SECTION.dwg, 5/3/2006 5:56:35 PM, Adobe PDF, 1:2

Figure 28
Typical Cross Section at Bear River, RM 10.1

Appendix B

Standard Assessment Methodology (SAM) Model Results
for
SRBPP Actions
at
Sacramento RMs 49.6, 49.9, 50.2, 50.4, 50.8, 51.5, 52.4, and 53.1

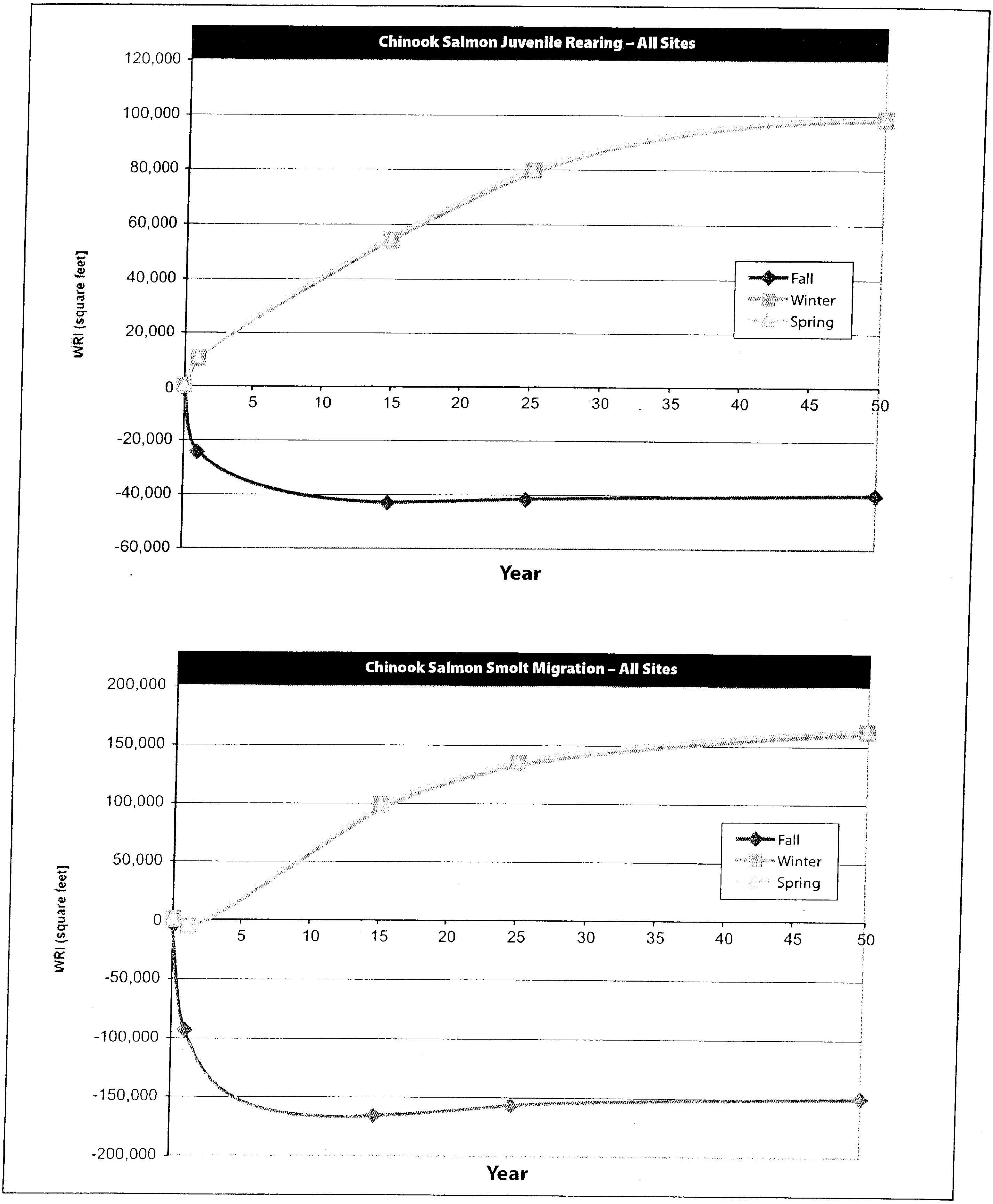


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Figure 1
Chinook Salmon SAM Response Indices for Pocket Bank Protection Sites

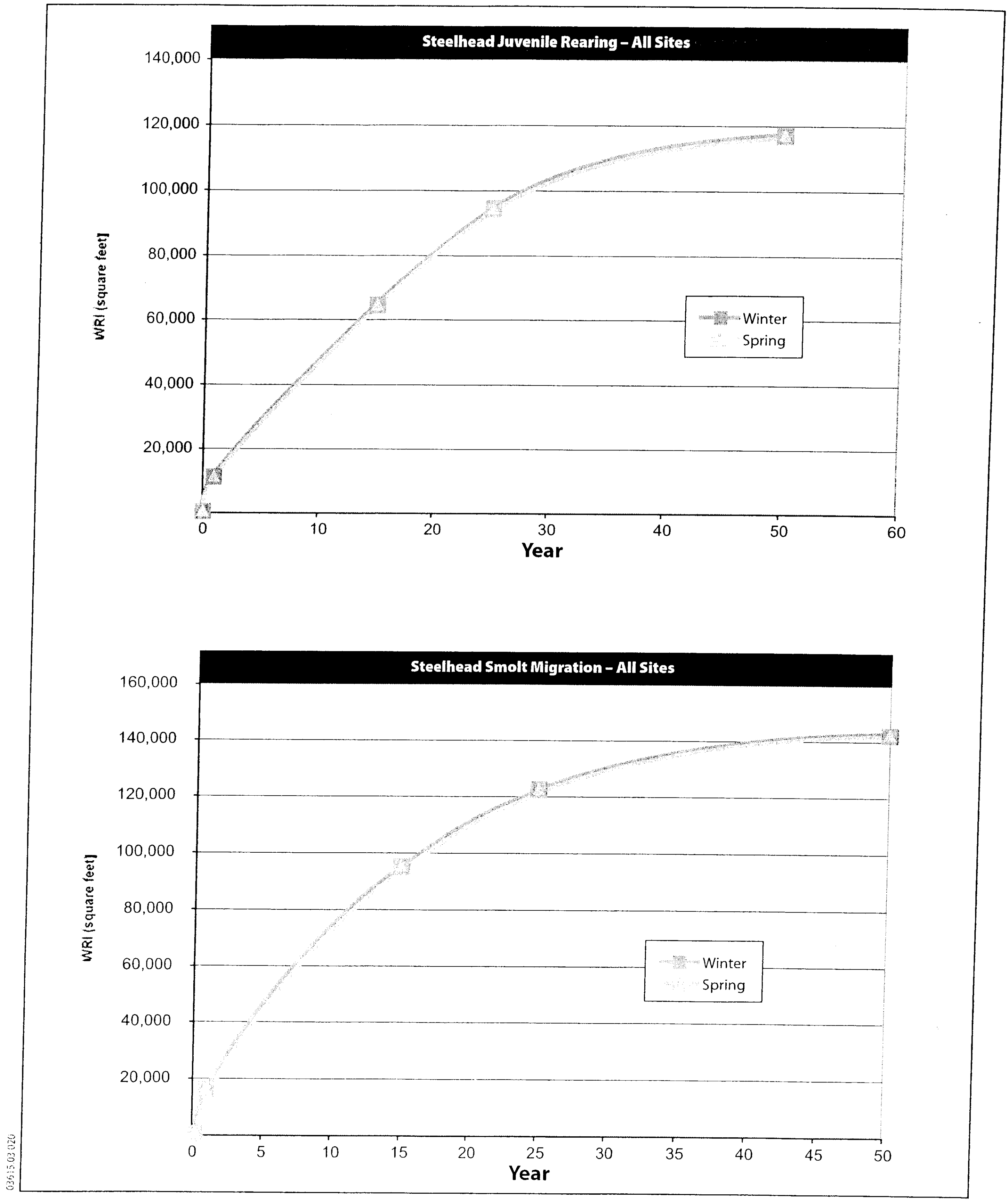

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Figure 2
Steelhead SAM Response Indices for Pocket Bank Protection Sites

CHINOOK		WRI (SQUARE FEET)								
	Year	RM 49.6	RM 49.9	RM 50.2	RM 50.4	RM 50.8	RM 51.5	RM 52.4	RM 53.1	Total
Fall	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile	1	-1936.05	-1786.03	-10089.01	-797.77	-4126.52	-4637.82	-387.38	-116.70	-23877.29
Rearing	15	-3513.67	-3261.01	-18327.77	-1355.99	-7547.07	-8421.18	-668.97	-191.52	-43287.18
	25	-3381.81	-3155.04	-17654.69	-1228.17	-7312.41	-8108.64	-615.33	-167.36	-41623.44
	50	-3282.91	-3075.56	-17149.88	-1132.31	-7136.41	-7874.23	-575.10	-149.24	-40375.63
Winter	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile	1	-1174.38	197.97	3814.34	3512.32	2839.46	-913.39	1221.36	364.54	9862.21
Rearing	15	55.91	1928.30	17822.20	8837.84	13611.49	6767.48	3636.04	1483.06	54142.32
	25	1685.75	2893.98	24944.54	10307.26	19663.49	13053.64	4578.84	2078.37	79205.86
	50	2908.12	3618.24	30286.29	11409.33	24202.48	17768.26	5285.94	2524.86	98003.52
Spring	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile	1	-1174.38	197.97	3814.34	3512.32	2839.46	-913.39	1221.36	364.54	9862.21
Rearing	15	55.91	1928.30	17822.20	8837.84	13611.49	6767.48	3636.04	1483.06	54142.32
	25	1685.75	2893.98	24944.54	10307.26	19663.49	13053.64	4578.84	2078.37	79205.86
	50	2908.12	3618.24	30286.29	11409.33	24202.48	17768.26	5285.94	2524.86	98003.52
Fall	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Smolt	1	-7088.79	-6815.05	-37055.96	-3624.19	-17126.42	-18352.63	-2211.31	-777.20	-93051.56
Migration	15	-12675.96	-12236.72	-66245.20	-6050.07	-30674.16	-32814.80	-3779.37	-1280.16	-165756.44
	25	-12041.77	-11667.22	-62916.31	-5381.35	-29181.32	-31170.64	-3441.67	-1122.94	-156923.22
	50	-11566.12	-11240.10	-60419.64	-4879.82	-28061.69	-29937.52	-3188.40	-1005.03	-150298.31
Winter	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Smolt	1	-2257.41	-2069.83	-1873.91	9056.67	-882.38	-8818.66	2045.01	907.16	-3893.34
Migration	15	2728.03	2096.13	31650.84	24338.94	20551.25	5812.34	8047.63	4025.69	99250.85
	25	5121.96	3438.44	41320.85	26462.34	29497.21	15058.67	9518.77	5093.12	135511.37
	50	6917.41	4445.17	48573.36	28054.89	36206.68	21993.42	10622.13	5893.70	162706.76
Spring	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Smolt	1	-2257.41	-2069.83	-1873.91	9056.67	-882.38	-8818.66	2045.01	907.16	-3893.34
Migration	15	2728.03	2096.13	31650.84	24338.94	20551.25	5812.34	8047.63	4025.69	99250.85
	25	5121.96	3438.44	41320.85	26462.34	29497.21	15058.67	9518.77	5093.12	135511.37
	50	6917.41	4445.17	48573.36	28054.89	36206.68	21993.42	10622.13	5893.70	162706.76
Fall	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adult	1	-1635.10	-2119.67	-8237.19	-2183.43	-3699.69	-4757.00	-628.44	-204.85	-23465.38
Migration	15	-2740.87	-3697.07	-13695.80	-3803.23	-6039.26	-8058.12	-978.92	-287.76	-39301.04
	25	-2448.20	-3432.83	-12131.92	-3527.00	-5247.14	-7273.97	-806.83	-206.60	-35074.49
	50	-2228.71	-3234.65	-10959.01	-3319.83	-4653.05	-6685.86	-677.76	-145.72	-31904.58
Winter	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adult	1	-2081.86	-1391.59	-4577.38	-130.34	-505.07	-3097.00	1349.22	714.95	-9719.07
Migration	15	-2997.76	-2111.53	-4678.22	548.28	2451.22	-2453.38	3219.32	1783.09	-4238.97
	25	-2231.54	-1685.54	-1463.18	1185.03	5179.91	291.35	3743.97	2122.84	7142.83
	50	-1656.87	-1366.05	948.10	1662.59	7226.43	2349.89	4137.45	2377.65	15679.19
Spring	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adult	1	-2081.86	-1391.59	-4577.38	-130.34	-505.07	-3097.00	1349.22	714.95	-9719.07
Migration	15	-2997.76	-2111.53	-4678.22	548.28	2451.22	-2453.38	3219.32	1783.09	-4238.97
	25	-2231.54	-1685.54	-1463.18	1185.03	5179.91	291.35	3743.97	2122.84	7142.83
	50	-1656.87	-1366.05	948.10	1662.59	7226.43	2349.89	4137.45	2377.65	15679.19

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Table 1
Chinook Salmon SAM Results for the Pocket Bank Protection Sites

STEELHEAD	Year	RM 49.6	RM 49.9	RM 50.2	RM 50.4	RM 50.8	RM 51.5	RM 52.4	RM 53.1	Total
		WRI (SQUARE FEET)								
Fall Juvenile Rearing (ns)	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-3047.22	-2863.77	-15973.35	-1588.59	-6946.88	-7514.53	-693.01	-212.84	-38840.19
	15	-5434.94	-5141.38	-28519.25	-2680.17	-12490.98	-13405.59	-1159.02	-332.86	-69164.19
	25	-5151.13	-4901.56	-27055.16	-2409.64	-11924.50	-12707.96	-1032.86	-275.63	-65458.44
	50	-4938.26	-4721.69	-25957.10	-2206.75	-11499.64	-12184.75	-938.24	-232.71	-62679.13
Winter Juvenile Rearing	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-1677.36	-6.52	3870.74	4440.27	3760.76	-1460.57	1762.36	565.03	11254.70
	15	-378.18	1835.82	20055.21	11037.54	17222.09	7612.84	5008.89	2097.25	64491.45
	25	1585.93	2956.46	28425.74	12769.07	24530.73	15175.47	6179.02	2858.28	94480.70
	50	3059.01	3796.94	34703.64	14067.71	30012.21	20847.44	7056.62	3429.05	116972.63
Spring Juvenile Rearing	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-1677.36	-6.52	3870.74	4440.27	3760.76	-1460.57	1762.36	565.03	11254.70
	15	-378.18	1835.82	20055.21	11037.54	17222.09	7612.84	5008.89	2097.25	64491.45
	25	1585.93	2956.46	28425.74	12769.07	24530.73	15175.47	6179.02	2858.28	94480.70
	50	3059.01	3796.94	34703.64	14067.71	30012.21	20847.44	7056.62	3429.05	116972.63
Winter Smolt Migration	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-894.69	139.33	5479.11	7605.17	2874.24	-2984.83	2668.31	1117.40	16004.04
	15	2665.27	3604.30	30945.18	18616.56	19544.74	8558.58	7742.02	3700.69	95377.34
	25	4493.68	4552.12	38109.19	20168.74	26267.24	15437.88	8901.90	4538.32	122469.07
	50	5864.99	5262.98	43482.20	21332.87	31309.12	20597.36	9771.81	5166.54	142787.87
Spring Smolt Migration	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-894.69	139.33	5479.11	7605.17	2874.24	-2984.83	2668.31	1117.40	16004.04
	15	2665.27	3604.30	30945.18	18616.56	19544.74	8558.58	7742.02	3700.69	95377.34
	25	4493.68	4552.12	38109.19	20168.74	26267.24	15437.88	8901.90	4538.32	122469.07
	50	5864.99	5262.98	43482.20	21332.87	31309.12	20597.36	9771.81	5166.54	142787.87
Fall Adult Migration	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-3416.05	-4525.92	-17516.95	-4665.24	-7723.56	-10347.02	-1178.94	-386.90	-49760.57
	15	-5718.25	-7922.74	-29189.73	-8167.75	-12722.29	-17654.44	-1821.91	-540.79	-83737.91
	25	-5100.46	-7381.53	-25915.75	-7610.77	-11160.32	-16050.53	-1487.46	-385.34	-75092.16
	50	-4637.12	-6975.63	-23460.26	-7193.04	-9988.84	-14847.59	-1236.62	-268.75	-68607.86
Winter Adult Migration	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-3758.45	-2185.15	-8155.53	-234.51	-1084.43	-6100.97	2896.32	1435.58	-17187.14
	15	-5524.74	-3323.43	-8996.61	848.46	3984.28	-5462.64	6623.23	3497.24	-8354.21
	25	-4231.68	-2660.75	-3797.49	1883.68	8820.03	-559.27	7519.41	4112.95	11086.87
	50	-3261.89	-2163.74	101.85	2660.10	12446.85	3118.25	8191.54	4574.73	25667.69
Spring Adult Migration	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	-3758.45	-2185.15	-8155.53	-234.51	-1084.43	-6100.97	2896.32	1435.58	-17187.14
	15	-5524.74	-3323.43	-8996.61	848.46	3984.28	-5462.64	6623.23	3497.24	-8354.21
	25	-4231.68	-2660.75	-3797.49	1883.68	8820.03	-559.27	7519.41	4112.95	11086.87
	50	-3261.89	-2163.74	101.85	2660.10	12446.85	3118.25	8191.54	4574.73	25667.69

ns = not present in signficant numbers

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Table 2
Steelhead SAM Results for the Pocket Bank Protection Sites

Appendix C

Standard Assessment Methodology (SAM) Model Results
for
SRBPP Actions
at
Sacramento River, RMs 26.9, 34.5, 72.2, 99.3, and 123.5

Table 1
SAM results at RM 26.9 showing wetted-area relative response in square feet

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	2350		973	7723		3034		1396	6564		2493		1171	6334		2350		973		
Year 5	2350		973	7723		3058		1432	6669		2493		1171	6334		2350		973		
Year 15	2578		1196	8279		3242		1705	7448		2660		1443	6960		2578		1197		
Year 25	2981		1561	8928		3464		2060	8261		3047		2056	7892		2981		1561		
Year 50	3697		2122	9688		3800		2610	9431		3749		3103	9162		3697		2123		
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	2350		973					1396	6564		2493			6334		2350				
Year 5	2350		973					1432	6669		2493			6334		2350				
Year 15	2578		1196					1705	7448		2660			6960		2578				
Year 25	2981		1561					2060	8261		3047			7892		2981				
Year 50	3697		2122					2610	9431		3749			9162		3697				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	2350			7723		3034			6564		2493		1171							
Year 5	2350			7723		3058			6669		2493		1171							
Year 15	2578			8279		3242			7448		2660		1443							
Year 25	2981			8928		3464			8261		3047		2056							
Year 50	3697			9688		3800			9431		3749		3103							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	2350		973	7723		3034		1396	6564		2493		1171	6334		2350		973		
Year 5	2350		973	7723		3058		1432	6669		2493		1171	6334		2350		973		
Year 15	2578		1196	8279		3242		1705	7448		2660		1443	6960		2578		1197		
Year 25	2981		1561	8928		3464		2060	8261		3047		2056	7892		2981		1561		
Year 50	3697		2122	9688		3800		2610	9431		3749		3103	9162		3697		2123		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	5610		1739		5610	6419		2268	4950	5690	5690		1831	4348	5690	5609		1741		5609
Year 5	5610		1739		5610	6472		2320	5026	5690	5690		1831	4348	5690	5609		1741		5609
Year 15	6052		2087		6052	6868		2719	5592	6028	6028		2208	4809	6028	6052		2089		6052
Year 25	6753		2640		6753	7318		3214	6201	6726	6726		3021	5593	6726	6752		2641		6752
Year 50	7860		3455		7860	7991		3970	7096	7904	7904		4392	6756	7904	7860		3486		7860
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-21164	-21164		0	0	-21320	-21320		0	0	16072	16072		0
Year 5	0				0	0	-21164	-21164		0	0	-21320	-21320		0	0	16072	16072		0
Year 15	0				0	0	-21164	-21164		0	0	-21320	-21320		0	0	16072	16072		0
Year 25	0				0	0	-21164	-21164		0	0	-21320	-21320		0	0	16072	16072		0
Year 50	0				0	0	-21164	-21164		0	0	-21320	-21320		0	0	16072	16072		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table 2
SAM results at RM 34.5 showing wetted-area relative response in square feet

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	1601		798	5736		1921		1215	6069		2259		1217	5940		1601		798		
Year 5	1601		798	5736		1921		1215	6091		2259		1217	5963		1601		798		
Year 15	1770		956	6236		2017		1349	6521		2381		1400	6483		1770		956		
Year 25	2071		1231	6849		2196		1622	7188		2665		1838	7271		2071		1231		
Year 50	2619		1678	7594		2458		2033	8117		3197		2620	8391		2619		1678		
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	1601		798					1215	6069		2259			5940		1601				
Year 5	1601		798					1215	6091		2259			5963		1601				
Year 15	1770		956					1349	6521		2381			6483		1770				
Year 25	2071		1231					1622	7188		2665			7271		2071				
Year 50	2619		1678					2033	8117		3197			8391		2619				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	1601			5736		1921			6069		2259		1217							
Year 5	1601			5736		1921			6091		2259		1217							
Year 15	1770			6236		2017			6521		2381		1400							
Year 25	2071			6849		2196			7188		2665		1838							
Year 50	2619			7594		2458			8117		3197		2620							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	1601		798	5736		1921		1215	6069		2259		1217	5940		1601		798		
Year 5	1601		798	5736		1921		1215	6091		2259		1217	5963		1601		798		
Year 15	1770		956	6236		2017		1349	6521		2381		1400	6483		1770		956		
Year 25	2071		1231	6849		2196		1622	7188		2665		1838	7271		2071		1231		
Year 50	2619		1678	7594		2458		2033	8117		3197		2620	8391		2619		1678		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	3521		1604		3521	4085		2175	4728	4219	4219		2150	4630	4219	3521		1604		3521
Year 5	3521		1604		3521	4085		2175	4731	4219	4219		2150	4632	4219	3521		1604		3521
Year 15	3870		1860		3870	4292		2375	5029	4476	4476		2413	4997	4476	3870		1860		3870
Year 25	4425		2287		4425	4662		2762	5532	5013	5013		3008	5639	5013	4425		2287		4425
Year 50	5319		2967		5319	5193		3335	6243	5940	5940		4049	6619	5940	5319		2967		5319
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	-14421	-14421		0	0	-14329	-14329		0	0	10284	10284		0
Year 5	0				0	0	-14421	-14421		0	0	-14329	-14329		0	0	10284	10284		0
Year 15	0				0	0	-14421	-14421		0	0	-14329	-14329		0	0	10284	10284		0
Year 25	0				0	0	-14421	-14421		0	0	-14329	-14329		0	0	10284	10284		0
Year 50	0				0	0	-14421	-14421		0	0	-14329	-14329		0	0	10284	10284		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table 3
SAM results at RM 72.2 showing wetted-area relative response in square feet

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	40		-2191	-5173		1361		2832	8556		301		-4102	-8440		40		-2179		
Year 5	40		-2191	-5173		1361		2832	8961		301		-4102	-8132		40		-2179		
Year 15	460		-1964	-4461		1621		3442	10471		608		-3747	-7009		460		-1952		
Year 25	1204		-1596	-3631		2080		4582	12444		1277		-2999	-5662		1204		-1583		
Year 50	2522		-1029	-2659		2739		6254	15112		2538		-1676	-3785		2522		-1017		
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	40		-2191					2832	8556		301			-8440		40				
Year 5	40		-2191					2832	8961		301			-8132		40				
Year 15	460		-1964					3442	10471		608			-7009		460				
Year 25	1204		-1596					4582	12444		1277			-5662		1204				
Year 50	2522		-1029					6254	15112		2538			-3785		2522				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	40			-5173		1361			8556		301		-4102							
Year 5	40			-5173		1361			8961		301		-4102							
Year 15	460			-4461		1621			10471		608		-3747							
Year 25	1204			-3631		2080			12444		1277		-2999							
Year 50	2522			-2659		2739			15112		2538		-1676							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0		
Year 1	40		-2191	-5173		1361		2832	8556		301		-4102	-8440		40		-2179		
Year 5	40		-2191	-5173		1361		2832	8961		301		-4102	-8132		40		-2179		
Year 15	460		-1964	-4461		1621		3442	10471		608		-3747	-7009		460		-1952		
Year 25	1204		-1596	-3631		2080		4582	12444		1277		-2999	-5662		1204		-1583		
Year 50	2522		-1029	-2659		2739		6254	15112		2538		-1676	-3785		2522		-1017		
Central Valley steelhead																				
Year 0	0		0		0	0		0	0	0	0		0	0	0	0		0		0
Year 1	854		-3309		854	2625		4274	7799	1014	1014		-5088	-5978	1014	854		-3290		854
Year 5	854		-3309		854	2625		4275	7872	1014	1014		-5087	-5917	1014	854		-3290		854
Year 15	1668		-2898		1668	3181		5060	8793	1635	1635		-4546	-5124	1635	1668		-2879		1668
Year 25	2956		-2247		2956	4121		6475	10222	2844	2844		-3453	-3890	2844	2956		-2228		2956
Year 50	4991		-1252		4991	5445		8521	12193	4955	4955		-1546	-2012	4955	4991		-1233		4991
Delta Smelt																				
Year 0	0				0	0	0	0		0	0	0	0		0	0	0	0		0
Year 1	0				0	0	57510	57510		0	0	48969	48969		0	0	33065	33065		0
Year 5	0				0	0	57514	57514		0	0	48974	48974		0	0	33065	33065		0
Year 15	0				0	0	57516	57516		0	0	48975	48975		0	0	33065	33065		0
Year 25	0				0	0	57517	57517		0	0	48976	48976		0	0	33065	33065		0
Year 50	0				0	0	57517	57517		0	0	48976	48976		0	0	33065	33065		0

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table 4
SAM results at RM 99.3 showing wetted-area relative response in square feet

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0			0		0	0		0		0	0		0		0		
Year 1	2209		223			2209		1759	6571		2209		1767	6347		2209		214		
Year 5	2209		223			2221		1787	6728		2209		1768	6443		2209		214		
Year 15	2342		287			2314		2004	7228		2301		1998	6940		2342		278		
Year 25	2580		406			2438		2328	7768		2518		2578	7715		2580		397		
Year 50	3020		605			2632		2846	8578		2931		3647	8845		3020		596		
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	2209		223					1759	6571		2209			6347		2209				
Year 5	2209		223					1787	6728		2209			6443		2209				
Year 15	2342		287					2004	7228		2301			6940		2342				
Year 25	2580		406					2328	7768		2518			7715		2580				
Year 50	3020		605					2846	8578		2931			8845		3020				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	2209			1676		2209			6571		2209		1767							
Year 5	2209			1676		2221			6728		2209		1768							
Year 15	2342			1976		2314			7228		2301		1998							
Year 25	2580			2360		2438			7768		2518		2578							
Year 50	3020			2846		2632			8578		2931		3647							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	2209		223	1676		2209		1759	6571		2209		1767	6347		2209		214	1607	
Year 5	2209		223	1676		2221		1787	6728		2209		1768	6443		2209		214	1607	
Year 15	2342		287	1976		2314		2004	7228		2301		1998	6940		2342		278	1907	
Year 25	2580		406	2360		2438		2328	7768		2518		2578	7715		2580		397	2292	
Year 50	3020		605	2846		2632		2846	8578		2931		3647	8845		3020		596	2777	
Central Valley steelhead																				
Year 0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0
Year 1	4422		542	1779	4422	4422		2808	5543	4422	4422		2793	5285	4422	4422		522	1693	4422
Year 5	4422		542	1779	4422	4449		2845	5605	4422	4422		2794	5304	4422	4422		522	1693	4422
Year 15	4707		667	2065	4707	4653		3129	5941	4623	4707		3089	5636	4623	4707		647	1979	4707
Year 25	5163		885	2463	5163	4908		3528	6335	5043	5163		3782	6232	5043	5163		865	2377	5163
Year 50	5907		1244	3009	5907	5302		4159	6932	5780	5907		5026	7158	5780	5907		1224	2923	5907
Delta Smelt																				
Year 0	*Delta smelt not modeled upstream of Reach 1 (RM 0-80)*																			
Year 1																				
Year 5																				
Year 15																				
Year 25																				
Year 50																				

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Table 5
SAM results at RM 123.5 showing wetted-area relative response in square feet

Focus Fish Species and Scenario	Fall (September-November)					Winter (December-February)					Spring (March-May)					Summer (June-August)				
	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat	Adult Upstream Migration	Spawning and Incubation	Juvenile Rearing	Smolt Outmigration	Adult Habitat
Central Valley spring-run chinook salmon																				
Year 0	0		0			0		0	0		0		0	0		0		0		
Year 1	1511		169			1529		1407	5190		1517		439	2170		1502		165		
Year 5	1511		169			1537		1427	5306		1517		439	2221		1502		165		
Year 15	1603		210			1602		1587	5678		1581		507	2477		1597		207		
Year 25	1767		284			1687		1824	6059		1730		678	2855		1763		283		
Year 50	2070		409			1822		1944	6042		2016		990	3402		2068		408		
Central Valley fall-run chinook salmon																				
Year 0	0		0					0	0		0			0		0				
Year 1	1511		169					1407	5190		1517			2170		1502				
Year 5	1511		169					1427	5306		1517			2221		1502				
Year 15	1603		210					1587	5678		1581			2477		1597				
Year 25	1767		284					1824	6059		1730			2855		1763				
Year 50	2070		409					1944	6042		2016			3402		2068				
Central Valley late fall-run chinook salmon																				
Year 0	0			0		0			0		0		0							
Year 1	1511			1402		1529			5190		1517		439							
Year 5	1511			1402		1537			5306		1517		439							
Year 15	1603			1602		1602			5678		1581		507							
Year 25	1767			1858		1687			6059		1730		678							
Year 50	2070			2179		1822			6042		2016		990							
Sacramento River winter-run chinook salmon																				
Year 0	0		0	0		0		0	0		0		0	0		0		0	0	
Year 1	1511		169	1402		1529		1407	5190		1517		439	2170		1502		165	1381	
Year 5	1511		169	1402		1537		1427	5306		1517		439	2221		1502		165	1381	
Year 15	1603		210	1602		1602		1587	5678		1581		507	2477		1597		207	1589	
Year 25	1767		284	1858		1687		1824	6059		1730		678	2855		1763		283	1850	
Year 50	2070		409	2179		1822		1944	6042		2016		990	3402		2068		408	2175	
Central Valley steelhead																				
Year 0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0
Year 1	3028		422	1494	3028	3062		2257	4467	3039	3007		880	2041	3039	3007		414	1474	3007
Year 5	3028		422	1494	3028	3081		2284	4511	3039	3007		880	2051	3039	3007		414	1474	3007
Year 15	3224		503	1687	3224	3222		2491	4748	3178	3210		990	2236	3178	3210		498	1674	3210
Year 25	3537		644	1955	3537	3398		2779	5023	3467	3529		1248	2564	3467	3529		641	1947	3529
Year 50	4048		875	2320	4048	3670		2931	5059	3975	4044		1710	3072	3975	4044		874	2316	4044
Delta Smelt																				
Year 0	*Delta smelt not modeled upstream of Reach 1 (RM 0-80)*																			
Year 1																				
Year 5																				
Year 15																				
Year 25																				
Year 50																				

Notes: 1 Dark shading represents seasons in which various life stages are not found in the modeled reach of the Sacramento River.
2 Results calculated from time-averaged relative responses (with minus without project) to changes in each of six habitat variables used in the SAM (Stillwater Sciences 2006).

Appendix D

Standard Assessment Methodology (SAM) Model Results
for
CDWR Actions
at
Sacramento River, RMs 20.8, 25.5, 32.5, 56.8, 69.9, 85.6, 130.8, 141.4, 145.9, 154.5, and 164
Cache Slough RMs 16.5, and 21.8
Steamboat Slough RM 16.2
and
Bear River RMs 2.4, and 10.1

Table 1. Area-weighted SAM WRI values at RM 20.8

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	-6433.80	-11504.22	-16720.78	-23044.37
5	-8149.48	-12951.10	-21179.66	-24890.49
15	-12438.68	-16568.30	-32326.85	-29505.79
25	-12652.37	-15113.28	-33205.83	-25421.43
50	-12865.29	-13922.12	-34406.45	-22327.49

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	-17209.76	-7566.06
5	-18395.07	-8244.50
15	-21358.33	-9940.59
25	-18010.06	-8986.39
50	-15063.35	-8376.02

Table 2. Area-weighted SAM WRI values at RM 26.5

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	-1154.65	-1710.34	-6595.28	-9385.98
5	-1462.56	-1042.85	-8354.02	-8334.90
15	-2232.33	625.86	-12750.88	-5707.19
25	-2293.04	2058.50	-13219.71	-1730.29
50	-2375.96	2898.97	-13937.52	1057.28

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	-2878.42	-7152.78
5	-1921.65	-5758.98
15	470.28	-2274.47
25	2562.57	1189.71
50	3813.42	3356.92

Table 3. Area-weighted SAM WRI values at RM 32.5

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	-6510.77	-9742.83	-15832.70	-33665.96
5	-8246.98	-3611.00	-20054.75	-22835.87
15	-12587.49	11718.57	-30609.89	4239.36
25	-13260.74	16716.85	-34023.17	13388.59
50	-14390.22	17764.85	-40321.97	14021.69

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	-14337.88	-18832.28
5	-7087.43	-9400.88
15	11038.72	14177.63
25	16977.05	21216.76
50	18097.87	23441.43

Table 4. Area-weighted SAM WRI values at RM 56.8

RM 56.8 WRI Values (area weighted - square feet)

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-2610.34	-7279.01	-9150.66	-4632.31	-19150.59	-21177.01
5	-2812.99	-6718.83	-8804.78	-1320.14	-17716.61	-20323.11
15	-3319.63	-5318.38	-7940.09	6960.27	-14131.65	-18188.39
25	-3687.97	-3221.42	-6101.43	6779.75	-9508.21	-14342.06
50	-4553.51	-1598.93	-5253.56	4478.09	-6836.55	-13113.29

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	-9783.01	-11672.31	-12994.07	-13740.48
5	-8995.16	-11186.40	-11670.59	-12620.52
15	-7025.55	-9971.64	-8361.89	-9820.62
25	-4404.56	-7764.37	-4827.60	-6853.21
50	-2491.43	-6832.91	-2111.96	-5241.98

Table 5. Area-weighted SAM WRI values at RM 69.9

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	1296.30	7664.77	6434.90	8649.09	27992.91	17737.44
5	2440.82	14689.51	13869.81	13461.21	50354.21	35396.20
15	5302.14	32251.37	32457.11	25491.50	106257.45	79543.10
25	7091.11	36260.59	39007.45	30387.67	117249.93	92938.81
50	7829.89	38419.80	41297.32	31121.80	121873.06	99207.14

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	14119.93	11552.26	26163.54	17584.70
5	24960.40	22303.25	44369.67	33188.13
15	52061.60	49180.71	89884.97	72196.72
25	57488.53	57648.41	98554.93	83983.15
50	60258.57	60721.94	103799.43	90440.72

Table 6. Area-weighted SAM WRI values at RM 85.6

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-14.53	2215.90	2088.84	-1207.64	3642.37	1493.89
5	298.89	4903.20	5134.51	-489.96	10630.34	7334.41
15	1082.43	11621.43	12748.70	1304.23	28100.26	21935.72
25	1729.51	13247.65	15609.52	3188.95	32279.75	27481.28
50	1913.66	14067.66	16650.45	3359.65	33881.79	30132.60

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	3684.11	3340.97	4357.84	2967.90
5	7613.29	7546.06	10054.89	8353.92
15	17436.25	18058.79	24297.49	21818.98
25	19596.87	21712.66	27573.90	26690.56
50	20624.46	23086.08	29448.88	29376.46

Table 7. Area-weighted SAM WRI values at RM 130.8

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	1753.08	3174.34	2217.44	10038.00	9439.04	5111.11
5	2220.57	6245.35	4866.28	12714.80	18396.67	12442.83
15	3389.29	13922.86	11488.37	19406.80	40790.76	30772.11
25	3237.71	16350.86	13287.80	18589.39	46838.94	35314.66
50	2876.11	18598.33	14497.92	16619.98	51517.64	37646.69

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	5580.53	3880.73	9067.76	5451.03
5	10203.87	7815.72	16217.29	11351.02
15	21762.23	17653.20	34091.13	26101.01
25	24994.21	20034.43	38469.18	29662.64
50	27898.55	21546.87	42194.02	32160.15

Table 8. Area-weighted SAM WRI values at RM 141.4

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	319.60	11203.26	5221.14	2287.89	27981.92	5221.14
5	404.83	21149.17	11397.19	2897.99	49338.73	11397.19
15	617.90	46013.95	26837.33	4423.25	102730.75	26837.33
25	447.85	53022.39	29790.27	3079.37	114898.21	29790.27
50	97.09	58837.22	30440.59	315.34	122976.23	30440.59

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	17897.05	9272.81	24298.10	13484.01
5	31234.41	18271.58	40657.99	26406.75
15	64577.80	40768.50	81557.71	58713.60
25	72711.13	44663.74	90457.28	63803.16
50	79165.14	45524.88	97571.28	65478.38

Table 9. Area-weighted SAM WRI values at RM 145.9

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	2344.78	2227.54	0.00	1375.86	1307.07
5	0.00	2970.05	2821.55	0.00	1742.75	1655.62
15	0.00	4533.23	4306.57	0.00	2659.99	2526.99
25	0.00	4595.76	4365.97	0.00	2696.68	2561.85
50	0.00	4642.66	4410.52	0.00	2724.20	2587.99

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	2512.78	2387.14	1365.14	1296.89
5	3182.85	3023.71	1729.18	1642.72
15	4858.04	4615.13	2639.28	2507.31
25	4925.04	4678.79	2675.68	2541.90
50	4975.30	4726.53	2702.98	2567.84

Table 10. Area-weighted SAM WRI values at RM 154.5

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	271.96	3886.64	3502.59	2467.62	11856.89	8077.39
5	344.49	7644.10	7499.19	3125.65	21564.51	15834.93
15	525.80	17037.74	17490.68	4770.73	45833.56	35228.77
25	431.12	19909.77	20880.79	4046.13	51814.53	40899.22
50	232.69	22462.98	21869.80	2514.67	56162.16	43332.06

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	6455.89	5551.78	10202.01	8362.31
5	11830.91	10913.31	17683.91	15285.94
15	25268.46	24317.14	36388.69	32595.02
25	28894.09	28463.42	40752.46	37507.13
50	31998.90	29751.94	44381.04	39944.19

Table 11. Area-weighted SAM WRI values at RM 164

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-490.75	1358.89	900.86	-3768.57	1274.67	-2162.87
5	-621.62	3758.33	3287.93	-4773.53	7194.81	2004.47
15	-948.79	9756.93	9255.59	-7285.91	21995.16	12422.81
25	-1049.14	11661.56	11527.94	-8091.71	26419.98	16944.59
50	-1233.48	13133.70	12064.87	-9577.69	29072.95	18746.43

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	2330.20	1413.91	1611.48	54.18
5	5782.22	4671.74	6157.13	4164.66
15	14412.27	12816.32	17521.25	14440.85
25	16880.28	15761.76	20901.29	18322.57
50	18692.76	16543.99	23493.88	19880.92

Table 12. Area-weighted SAM WRI values at Cache Slough RM 32.5

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	-10.58	-24.56	-40.13	-87.89
5	-13.41	-30.01	-50.83	-108.19
15	-20.46	-43.63	-77.59	-158.92
25	-18.70	-41.38	-73.18	-153.54
50	-14.82	-39.92	-63.03	-150.84

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	-35.55	-66.16
5	-42.96	-80.55
15	-61.49	-116.51
25	-57.04	-109.42
50	-54.19	-104.43

Table 13. Area-weighted SAM WRI values at Cache Slough RM 21.8

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	-14.00	-39.10	-99.12	-261.85
5	-17.73	-47.51	-125.55	-321.54
15	-27.07	-68.53	-191.64	-470.77
25	-27.98	-64.93	-199.09	-455.19
50	-29.35	-63.51	-210.68	-450.76

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	-69.19	-221.62
5	-83.29	-269.59
15	-118.53	-389.51
25	-110.31	-371.13
50	-106.81	-365.92

Table 14. Area-weighted SAM WRI values at Steamboat Slough RM 16.2

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	23.03	-30.25	76.71	-1319.23
5	29.17	-6.50	97.17	-1356.85
15	44.52	52.89	148.31	-1450.90
25	36.32	254.96	64.03	-516.31
50	19.15	627.66	-107.10	905.90

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	14.95	-1001.05
5	84.89	-939.44
15	259.72	-785.44
25	638.79	113.92
50	1328.39	1491.19

Table 15. Area-weighted SAM WRI values at Bear River RM 2.4

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	-14.39	8.48	-65.85	-27.36
5	-16.98	17.96	-78.06	-17.51
15	-23.48	41.67	-108.59	7.11
25	-21.65	46.69	-101.75	22.46
50	-21.86	44.63	-104.60	25.35

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	14.38	-13.20
5	27.36	-2.67
15	59.82	23.67
25	66.02	37.40
50	62.98	43.18

Table 16. Area-weighted SAM WRI values at Bear River RM 10.1

Chinook Salmon

	Juvenile Rearing		Smolt Migration	
Year	Fall	Winter-Spring	Fall	Winter-Spring
0	0.00	0.00	0.00	0.00
1	2.79	28.21	21.01	42.02
5	8.56	39.32	40.53	66.99
15	22.99	67.11	89.30	129.43
25	26.67	72.15	93.23	142.81
50	28.23	73.37	88.92	144.80

Steelhead

	Juvenile Rearing	Smolt Migration
Year	Winter-Spring	Winter-Spring
0	0.00	0.00
1	41.30	42.19
5	56.91	62.60
15	95.94	113.61
25	102.16	123.68
50	103.23	127.95

Table 17. Summary of SAM WRI values for each site with total values for fall and winter flow elevations

Chinook Salmon	Year	Total WRI (square feet)	Total WRI Fall+Winter/Spring
Fall	0	0	
Juvenile	1	-13587.04639	
Rearing	5	-15594.42327	
	15	-20612.86547	
	25	-20011.30691	
	50	-22487.68296	
Winter-	0	0	0
Spring	1	1554.960206	-12032.08619
Juvenile	5	37009.1907	21414.76743
Rearing	15	125644.7669	105031.9015
	25	155756.7024	135745.3955
	50	175947.3396	153459.6567
Fall	0	0	
Smolt	1	-25422.06769	
Migration	5	-24089.17676	
	15	-20756.94943	
	25	-22685.92133	
	50	-40230.59578	
Winter-	0	0	0
Spring	1	-3337.547396	-28759.61509
Smolt	5	83707.0737	59617.89694
Migration	15	301318.6264	280561.677
	25	367966.9267	345281.0054
	50	404597.416	364366.8202

Steelhead	Year	Total WRI (square feet)
Winter-	0	0
Spring	1	8337.298505
Juvenile	5	58451.56209
Rearing	15	183737.2211
	25	223254.7752
	50	249303.7908
Winter-	0	0
Spring	1	29260.85497
Smolt	5	100565.4708
Migration	15	278827.0102
	25	327771.64
	50	361093.8435

Table 18. Bankline-weighted SAM WRI values at Sacramento RM 43.1.

WRI Values (bankline-weighted values; feet)

Chinook Salmon

Year	Juvenile Rearing Fall	Juvenile Rearing Winter	Juvenile Rearing Spring	Smolt Migration Fall	Smolt Migration Winter	Smolt Migration Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-3.70	-19.05	-14.60	-13.56	-34.27	-29.96
5	-3.36	-15.23	-7.75	-2.25	-18.41	-11.74
15	-2.51	-5.67	9.38	26.03	21.23	33.83
25	-3.41	1.08	16.54	25.48	38.60	50.51
50	-5.67	6.34	20.62	17.96	48.85	57.99

Steelhead

Year	Juvenile Rearing Winter	Juvenile Rearing Spring	Smolt Migration Winter	Smolt Migration Spring
0	0.00	0.00	0.00	0.00
1	-29.32	-18.14	-41.01	-28.90
5	-24.61	-8.57	-33.29	-16.99
15	-12.86	15.37	-13.99	12.80
25	-4.14	24.42	-1.19	25.09
50	2.27	29.33	8.67	32.65

Delta smelt

Year	Spawning/Incubation Winter	Spawning/Incubation Spring
0	0.00	0.00
1	-274.47	0.53
5	-347.44	6.55
15	-529.88	21.62
25	-537.07	24.02
50	-542.48	23.97

Note: Year 5 is a value derived from linear interpolation between Year 1 and Year 15 (due to computational processes inherent in the SAM model code)

Table 19. Bankline-weighted SAM WRI values at Sacramento RM 56.1.

WRI Values (bankline-weighted values; feet)

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-8.68	-11.97	-6.71	-30.85	-23.55	-11.29
5	-9.98	-7.68	1.15	-26.86	-8.75	8.15
15	-13.25	3.04	20.79	-16.87	28.24	56.75
25	-14.09	8.82	27.38	-17.85	43.03	71.41
50	-15.93	13.32	31.18	-24.40	51.78	78.11

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	-15.76	-8.12	-23.04	-9.29
5	-9.43	2.35	-13.45	4.95
15	6.39	28.51	10.52	40.56
25	13.96	36.65	21.63	51.44
50	19.54	41.12	30.18	58.19

Delta smelt

	Spawning/Incubation	
Year	Winter	Spring
0	0.00	0.00
1	1.28	230.69
5	1.81	297.23
15	3.12	463.58
25	3.26	471.77
50	3.36	476.33

Note: Year 5 is a value derived from linear interpolation between Year 1 and Year 15
(due to computational processes inherent in the SAM model code)

Table 20. Area-weighted SAM WRI values at Butte Creek RM 14.

site length: 2 banks @ 1005' each = 2010 total feet

WRI Values (bankline-weighted values; feet)

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-94.63	-38.97	-62.44	-113.93	-93.38	-104.29
5	-115.55	-38.22	-71.96	-126.71	-88.70	-106.79
15	-167.86	-36.36	-95.77	-158.67	-76.98	-113.03
25	-158.01	-29.52	-88.75	-127.14	-58.29	-92.00
50	-146.93	-25.59	-79.87	-101.79	-46.36	-74.37

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	-38.97	-62.44	-93.38	-104.29
5	-38.22	-71.96	-88.70	-106.79
15	-36.36	-95.77	-76.98	-113.03
25	-29.52	-88.75	-58.29	-92.00
50	-25.59	-79.87	-46.36	-74.37

Normalized WRI Values (bankline-weighted; WRI gains or losses per foot)

Chinook Salmon

	Juvenile Rearing			Smolt Migration		
Year	Fall	Winter	Spring	Fall	Winter	Spring
0	0.00	0.00	0.00	0.00	0.00	0.00
1	-0.05	-0.02	-0.03	-0.06	-0.05	-0.05
5	-0.06	-0.02	-0.04	-0.06	-0.04	-0.05
15	-0.08	-0.02	-0.05	-0.08	-0.04	-0.06
25	-0.08	-0.01	-0.04	-0.06	-0.03	-0.05
50	-0.07	-0.01	-0.04	-0.05	-0.02	-0.04

Steelhead

	Juvenile Rearing		Smolt Migration	
Year	Winter	Spring	Winter	Spring
0	0.00	0.00	0.00	0.00
1	-0.02	-0.03	-0.05	-0.05
5	-0.02	-0.04	-0.04	-0.05
15	-0.02	-0.05	-0.04	-0.06
25	-0.01	-0.04	-0.03	-0.05
50	-0.01	-0.04	-0.02	-0.04

Note: Year 5 is a value derived from linear interpolation between Year 1 and Year 15
(due to computational processes inherent in the SAM model code)